User's Manual 2.4 (October 2014)

SERIES 7000 Models

MODEL 7070, MODEL 7300
SERIES 7000

WARRANTY

Berkeley Nucleonics Corporation warrants all instruments, including component parts, to be free from defects in material and workmanship, under normal use and service for a period of one year. If repairs are required during the warranty period, contact the factory for component replacement or shipping instructions. Include the serial number of the instrument. This warranty is void if the unit is repaired or altered by others than those authorized by Berkeley Nucleonics Corporation.

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1 Introduction to the SERIES 7000

Your SERIES 7000 kit contains the following items:

- SERIES 7000 mainframe
- Universal power adaptor (AC 100 – 240V)
- Ethernet Cable
- SERIES 7000 software CD

It is strongly recommended to use the original power adaptor (as supplied with the device) to guarantee save and reliable operation of the SERIES 7000.

1.1 General Features and Functions

The different SERIES 7000 models offer different measurement capabilities as shown in the table below:

Model	SERIES 7000	MODEL 7070	MODEL 7300
RF frequency	5 MHz to 400	5 MHz to 7 GHz	5 MHz to 26 GHz
Offset range	0.1 Hz to 1 MHz	0.1 Hz to 50 MHz	0.1 Hz to 50 MHz
Absolute Phase Noise Mode	Y	Y	Y
Additive Phase Noise Mode	Y	Y	Y
Amplitude Noise Mode	Y	N	N
FFT Analyzer Mode	Y	Y	Y
Transient Measurement Mode	N	Y	Y

Features of all models include

- Long-term support: software upgrades (firmware and PC based) are available to download from www.BerkeleyNucleonics.com. You can also call our technical specialists for support. You can continue to use both of these services free of charge for the lifetime of the product.
- Universal LAN and USB 2.0 interface
- 24 months calibration cycle

1.2 Options

The following options are available for the SERIES 7000 signal analyzer:

GPIB	GPIB interface added
SUPPLY	Dual programmable low noise supply

LN Ultra Low close to carrier phase noise internal references

1.3 Front Panel Overview

Depending on the SERIES 7000 product configuration, the front panel can contain up to five female SMA connectors and two female BNC connectors. A green LED indicates the power on/off status of the instrument.

Figure 1 Front Panel View of the MODEL 7300

DUT/RF IN connector This female SMA connector is the DUT signal input. The input is AC-coupled and the impedance is 50 ohm. The damage level is +26 dBm maximum. The maximum allowed DC level is +/- 10 V.

Channel 1 and 2:

REF IN connector This female SMA connector is the reference LO input. The impedance is 50 ohm. The damage level is +20 dBm. The maximum allowed DC level is +/- 10 V.

REF OUT connector (SERIES 7000 ONLY) This female SMA connector is the reference LO output. The impedance is 50 ohm. **In standard operation with internal references the REF OUT is connected by a short semi-rigid cable to the REF IN.**

TUNE connector This female BNC connector is the DC tune voltage output if a tuneable DUT or tuneable external reference is used.

Power switch The power switch disconnects the instrument from the DC input completely.

Caution:

Do not apply a DC voltage or current to the individual ports of the DC Control, DC Power and RF Port. Applying a DC voltage or current may lead to the breakdown of this product. In particular, there is the risk of the capacitor remaining charged. Connect the measurement sample (DUT) to the port (or the test fixture, cables, etc. connected to the port) after discharging DUT's electricity enough.

1.4 Rear Panel Connections

In Figure 2 the rear panels is shown for different SERIES 7000 models.

Figure 2 Rear Panel Views of SERIES 7000 and MODEL 7300

Channel 1 and 2:

SUPPLY connector This female BNC connector is the programmable low-noise DC supply voltage output. SERIES 7000: *Output voltage range is 0 V to +5 V, maximum available current is 80 mA.* MODEL 7070/20G: Output voltage range is 0 V to +15 V, maximum available current is 500 mA.

BASEBAND IN connector This female BNC connector is the baseband signal input. To make baseband noise measurement mode useful for power supply noise measurement, this port is well protected for DC voltage application. The maximum allowed DC level is +/- 15 V.

LAN connector (8 Pin) This RJ-45 Host connector is used for connecting via Ethernet with a controller, such as a PC or Laptop. 10Base-T/100Base-T Ethernet (automatic data rate selection).

USB B connector Used for connecting with a controller such as a PC or Laptop. Communication is via USBTMC protocol. Through this port, you can control the SERIES 7000 from external controllers. For more information on the measurement system using the USB port, see the programmer's manual.

USB A connector Used for connecting USB devices such as Memory sticks.

DC IN power receptacle The power receptacle accepts a two-pin plug from the external 6 or 24 V DC power adapter.

GPIB (optional) connector The connection of an external controller through General Purpose Interface Bus (GPIB) connector allows you to configure an automatic measurement system. This GPIB connector is used only for controlling the SERIES 7000-IS from an external controller. You cannot control other devices from the SERIES 7000 through this GPIB connector.

Serial Number Plate The seal showing the serial number of the product.

2 Getting Started

2.1 System Requirements

To ensure that your SERIES 7000 signal analyzer operates correctly with the remote control interface software, you must have a computer with at least the minimum system requirements to run one of the supported operating systems.

Operating system Windows™ (XP SP2, 7, 8)
Minimum 2048 MB RAM
Ethernet Port 10/100/1000M LAN or USB 2.0 Port

2.2 Unpacking the SERIES 7000

Remove the SERIES 7000 materials from the shipping containers. Save the containers for future use.

2.3 Initial Inspection

Inspect the shipping container(s) for damage. If container is damaged, retain it until contents of the shipment have been verified against the packing list and instruments have been inspected for mechanical and electrical operation.

2.4 Starting the SERIES 7000

The following sections describe installation instructions and SERIES 7000 verification tests.

2.4.1 Applying Power

1. Place the SERIES 7000 on the intended workbench and connect the appropriate DC power supply to the receptacle on the rear of the unit. Make sure you use the included DC power supply. The SERIES 7000 requires 6 V DC at 6 A maximum. **Using other supplies may lead to malfunction and damage of the SERIES 7000.**
2. Press the Line on/off switch on the front panel. The green front panel "Power On" LED will illuminate. The instrument will boot and initialize within about 45. During the initialization process, the green "Ready" LED will start to flash. Once it stays on, the SERIES 7000 is ready for operation.

2.4.2 Connecting to LAN via DHCP Router

Connect the SERIES 7000 to your local area network (LAN) using the provided Ethernet cable. The instrument is configured to accept its dynamic IP number from the DHCP server of your network. If configured properly, your network router will assign a dynamic IP number to the instrument. Your instrument is now ready to be controlled.

2.4.3 Connecting via LAN without DHCP Router (fallback or fixed IP)

You can connect the instrument to your computer with the Ethernet cable without using a local area network with DHCP server. To work properly, the network controller (NIC) of your computer must be set to a **fixed IP beginning with** 169.254.xxx.xxx (excluding 169.254.1.0 and 169.254.254.255) and network mask 255.255.0.0 to match the fallback IP that the SERIES 7000 will assign itself after network timeout. The SERIES 7000 will automatically choose an IP address according to **ZEROCONF** standard. Therefore, the exact fallback address can't be predicted.

Connection from a NIC that is configured to use DHCP is also possible. After a preset timeout, the NIC will assume that no DHCP is available and self-assign a fallback IP that will fall into the range 169.254.xxx.xxx.

Alternatively, you may assign the instrument a fixed IP. Please refer to a later section of this manual to learn how to do this.

2.4.4 Connecting through USB to SERIES 7000 GUI

The SERIES 7000 can also be controlled under Windows with standard USBTMC drivers.
Connect the SERIES 7000 (USB B port) to the PC using a standard USB cable. The USB (IVI drivers) drivers are installed along with the GUI installation process that can be started from the provided installation CD or can be downloaded from the Berkeley Nucleonics website.
If installed properly, the Windows operating system will automatically detect the SERIES 7000 as a USBTMC device and the SERIES 7000 GUI will list it in its connection dialog.

2.4.5 Connecting through USBTMC & VISA

Connect the SERIES 7000 (USB B port) to the PC using a standard USB cable. Once connected properly, use VISA Write to send the *IDN? query and use VISA Read to get the response. The USBTMC protocol supports service request, triggers and other GPIB specific operations.
VISA now allows you to communicate as a controller to the SERIES 7000. To use such device, plug it in and Windows should detect the new hardware and launch the *New Hardware Wizard*. Instruct the wizard to search for the driver, which in this case is VISA. If the VISA runtime library is properly installed, the device will be installed as a USB Test & Measurement Class Device. Open Measurement & Automation Explorer (MAX). The new device will appear in MAX under Device and Interfaces » USB Devices. You can then use this resource name as you would use any GPIB resource.

2.4.6 Connecting through GPIB & VISA

Connect the SERIES 7000 to the rear GPIB connector (option GPIB). Once connected properly, use VISA Write to send the *IDN? query and use VISA Read to get the response. The protocol supports service request, triggers and other GPIB specific operations.
VISA now allows you to communicate as a controller to the SERIES 7000.

2.4.7 Using Berkeley Nucleonics Application Programming Interface (API)

Please refer to the SERIES 7000 Programmer's Manual to learn more about applying the API and programming examples.

2.4.8 Installing the SERIES 7000 Graphical User Interface Software

Berkeley Nucleonics's graphical user interface provides an intuitive control of the SERIES 7000. The Java based application runs under any Operating System including Windows™ 2000, XP, Vista, 7, or 8 with standard requirements. Only the Java runtime environment must be installed on the PC.
To install the GUI on the computer, insert the SERIES 7000 Software and Manual CD into the CD/DVD drive or download the latest GUI setup file from the Berkeley Nucleonics website. If the setup doesn't start automatically double click on the setup.exe to run the auto-installer.
The self-extracting setup provides easy installation and de-installation of the software. The setup program guides you in a few steps though the installation process. In case the Java Runtime Environment is not installed on your current computer, the setup procedure automatically will assist you with the installation of the required version. For this you will need an internet connection.

2.4.9 Troubleshooting

Software does not install or start properly

- Make sure your installation CD is not damaged.
- Verify that the Java Runtime Environment is installed and up to date

Software cannot detect any SERIES 7000

- Make sure you have connected both PC and SERIES 7000 to a common network. If they are not in the same subnet, the search won't show the SERIES 7000, but you can still connect by manually setting the IP in the connection dialog.
- If connecting with USB, make sure that the IVI drivers have been installed during GUI installation (default). The drivers can be reinstalled using the GUI setup procedure.
- Note that detection of the SERIES 7000 can take several seconds if your PC is configured to work with an external DHCP server but the DHCP is not available. In some cases the connection may even fail completely. Check your NIC configuration using IPCONFIG tool.

IPCONFIG /RELEASE and IPCONFIG /RENEW will update the NIC IP. Preferably work with fixed IP instead.

- Make sure that your (software) firewall enables the SERIES 7000 software to setup a TCP/IP connection within the LAN. Under Windows XP:
  Open *Control Panel* under *Settings* in your *Start* menu. Then go to *Windows Firewall*. Click on *Exceptions* and then *add Program.* If the SERIES 7000 Software is in this list choose it and click *OK* otherwise you have to browse for the path to Berkeley Nucleonics Software. Finally close all open dialogs with *OK*. Now your Windows™ Firewall is ready for SERIES 7000.

2.4.10 Shutting Down the SERIES 7000

Press the Line on/off switch on the rear panel (SERIES 7000) or the Power switch on the front panel (MODEL 7070/MODEL 7300) to power off.

2.4.11 Perform Firmware Upgrade

If the SERIES 7000 GUI has internet access, it will check for newer firmwares upon connection to an SERIES 7000. If there is a newer firmware available, the SERIES 7000 GUI will notify you. If you confirm the upgrade, the firmware will automatically be downloaded and installed on the SERIES 7000.
If the SERIES 7000 GUI has no internet access, a firmware upgrade of the SERIES 7000 can also be done manually via the GUI. Make sure you are connected to the right device and have the correct firmware binary ready. Then go to **Device → Update Firmware** and select the appropriate binary (tar.file) that you have received from Berkeley Nucleonics or downloaded from the Berkeley Nucleonics website. The update will take a few seconds, and after completion the device will reboot. Reconnect to the device and continue using the device.

Caution:

Do not switch off instrument or disconnect during the firmware upgrade procedure.

2.4.12 Serial Number

Each instrument owns a unique serial number which is shown on the sticker on the rear panel. This serial number is also internally stored and determines the instrument configuration and guides the software accordingly.

3 Measurement using the Graphical User Interface (GUI)

Berkeley Nucleonics's graphical user interface provides an intuitive control of the SERIES 7000. It runs under any operating system supporting a Java Runtime Environment (JRE). Make sure the software is installed and the computer's firewall configured as required.

3.1 Start the SERIES 7000 GUI

Double-click the SERIES 7000 shortcut that will appear on your desktop after the software has been successfully installed. Make sure that the SERIES 7000 is turned on and is connected to the computer using either Ethernet or USB connectivity.

After start, the software will automatically detect existing SERIES 7000 instruments (LAN and USB) and will establish connection to the previously connected device, if still available. Otherwise a window will appear with all detected SERIES 7000 devices listed. Connection to a device can be established by selecting the device identifier in the list and then clicking on the "select" button (see Figure 3). When this dialog is displayed, the GUI continuously searches and refreshes the list of available devices.

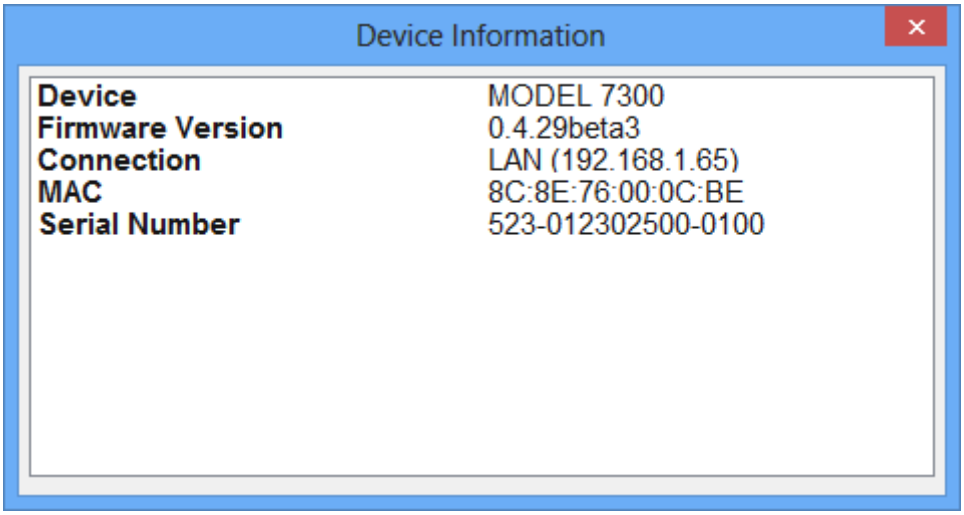


Figure 3 Device selection dialog

3.2 Organization of the GUI

The measurement window is organized as shown in Figure 4. The GUI is divided into three sections: a setup section on the top left, a plot configuration section on the top right and the actual measurement window on the bottom.

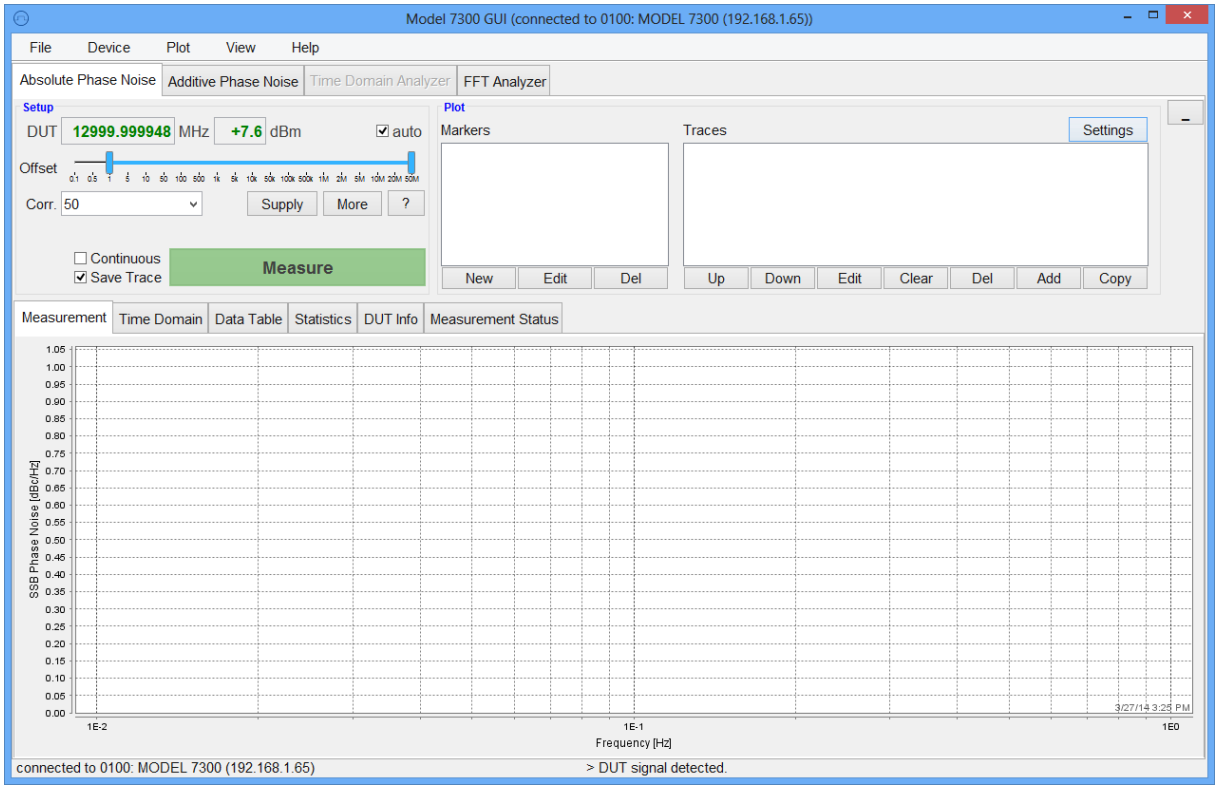
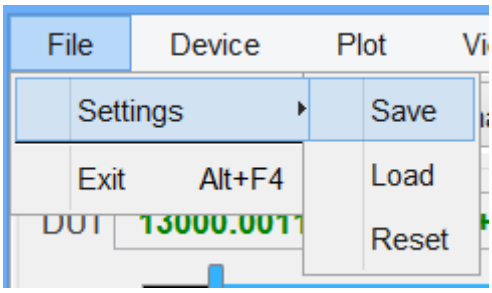


Figure 4 GUI after startup

3.2.1 Menu Section

On the top, the drop-down menus **File**, **Device**, **Plot**, **View**, and **Help** are available and are described below:

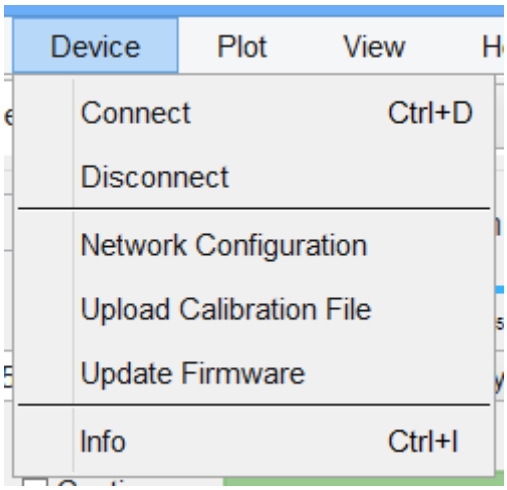


3.2.1.1 File

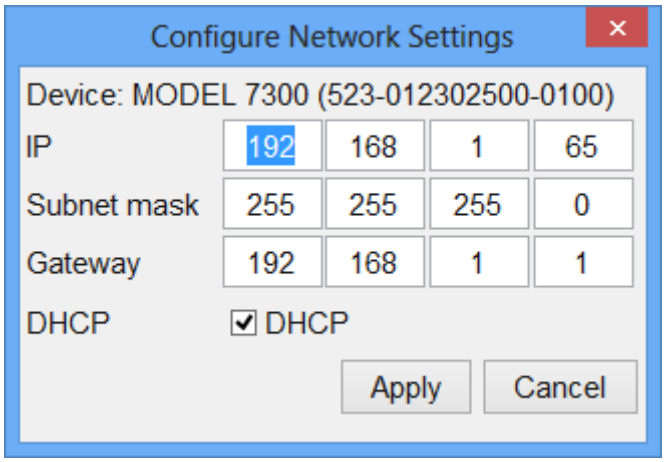
File → Setting → (Save, Load, Reset) allows storage and restoring of user defined parameter and measurement settings. When the GUI exits, the current configuration is automatically saved and restored at the next restart.

File → Exit will terminate the SERIES 7000 GUI software.

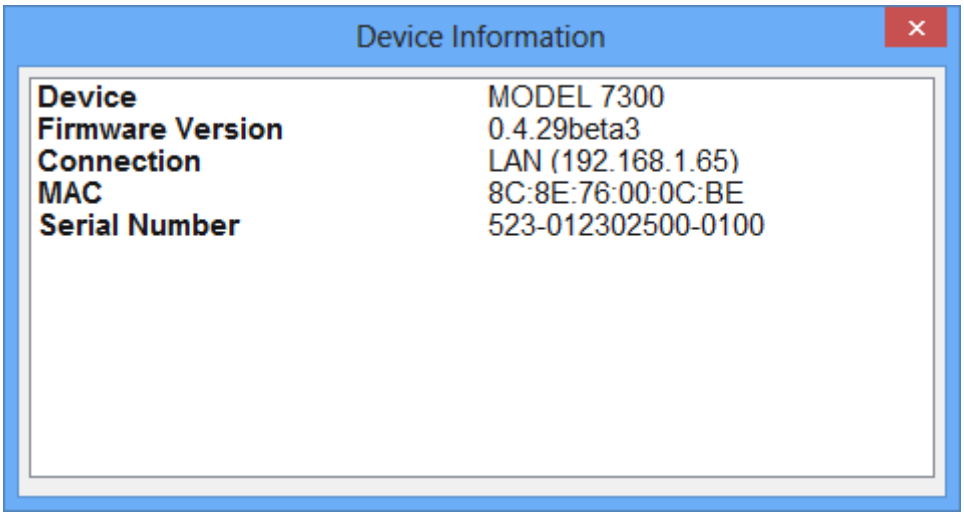
3.2.1.2 Device



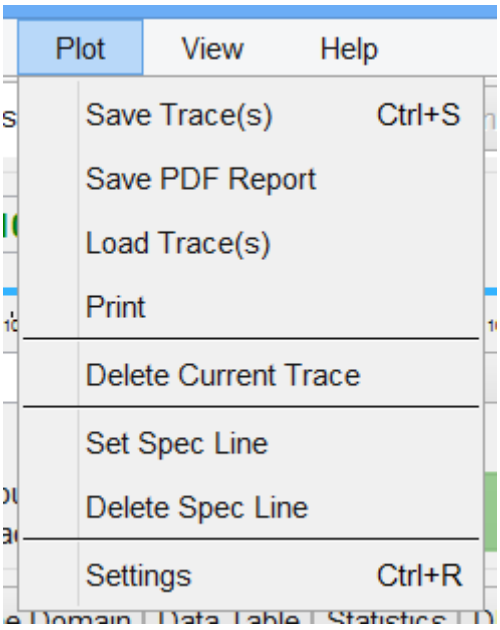
Device → Connect automatically detects available SERIES 7000 devices though LAN or USB. If a connection is already established, it disconnects and opens the dialog as shown in Figure 3.
Device → Disconnect will terminate an existing connection to an SERIES 7000 instrument.
Device → Network Configuration allows reconfiguration of instrument local area network settings such as IP, subnet mask, or gateway. Any change will be effective after subsequent hardware reboot of the device.



Device → Update Firmware performs firmware update. A dialog window will ask for firmware file (.tar). After selecting a correct firmware file, the update takes about 30 seconds. The GUI will disconnect from the instrument during the update process.
Device → Info provides product details of the instrument such as firmware version, instrument serial number and options installed as shown below.



3.2.1.3 Plot



Plot → Save, Load, & Print allows storing, loading, and printing of the plot window. Plots can be saved as PNG graphs or in SERIES 7000 internal mode (extension .Series 7000). They later can be loaded into the GUI. Data traces can be exported when saved as MATLAB™, MS EXCEL™ or CSV files (extension .csv).

Plot→ Save Report auto-generates a pdf report including measurement trace, jitter data, Allan Dev plot and phase noise, spurious and marker data of the current measurement.

Plot → Clear Trace deletes the active measurement trace. Same function

Plot → Clear Shadow

Plot → Set Spec Line opens a window dialog (see Figure 5). The dialog window allows defining and drawing a spec line into you measurement window. The data can be input manually in table format on the left or by clicking into the window on the right. Spec lines can be saved into and loaded from an external file.

Plot → Clear Spec Line deletes the currently loaded spec line

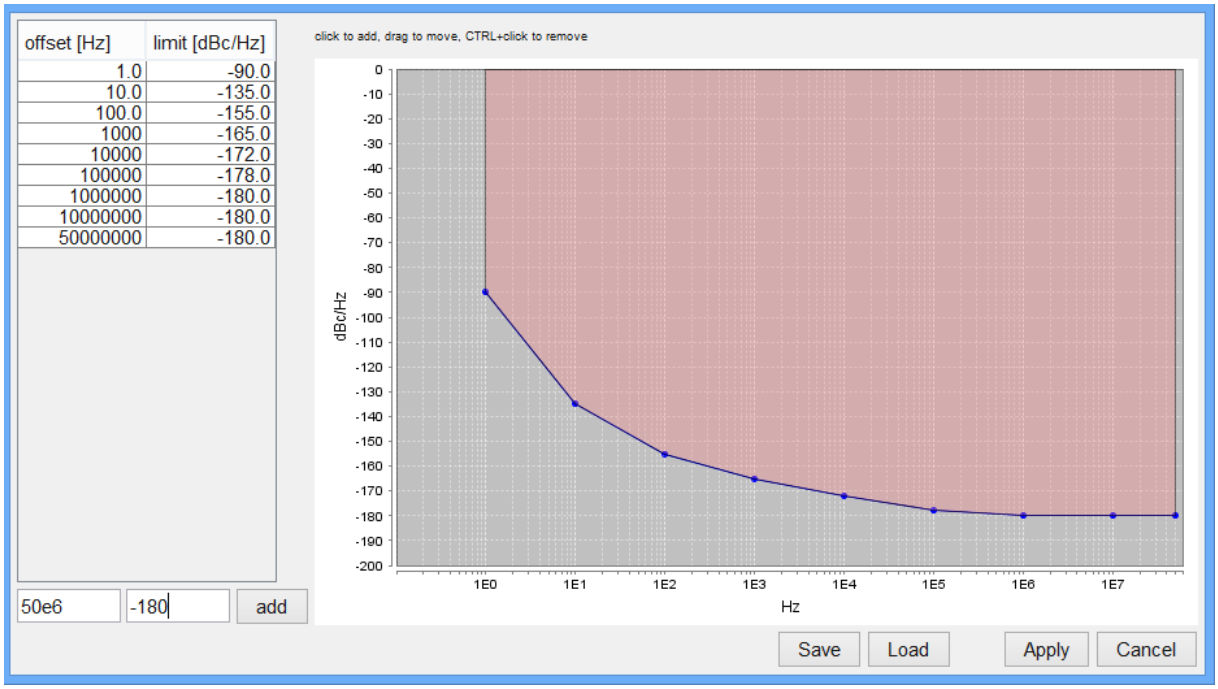
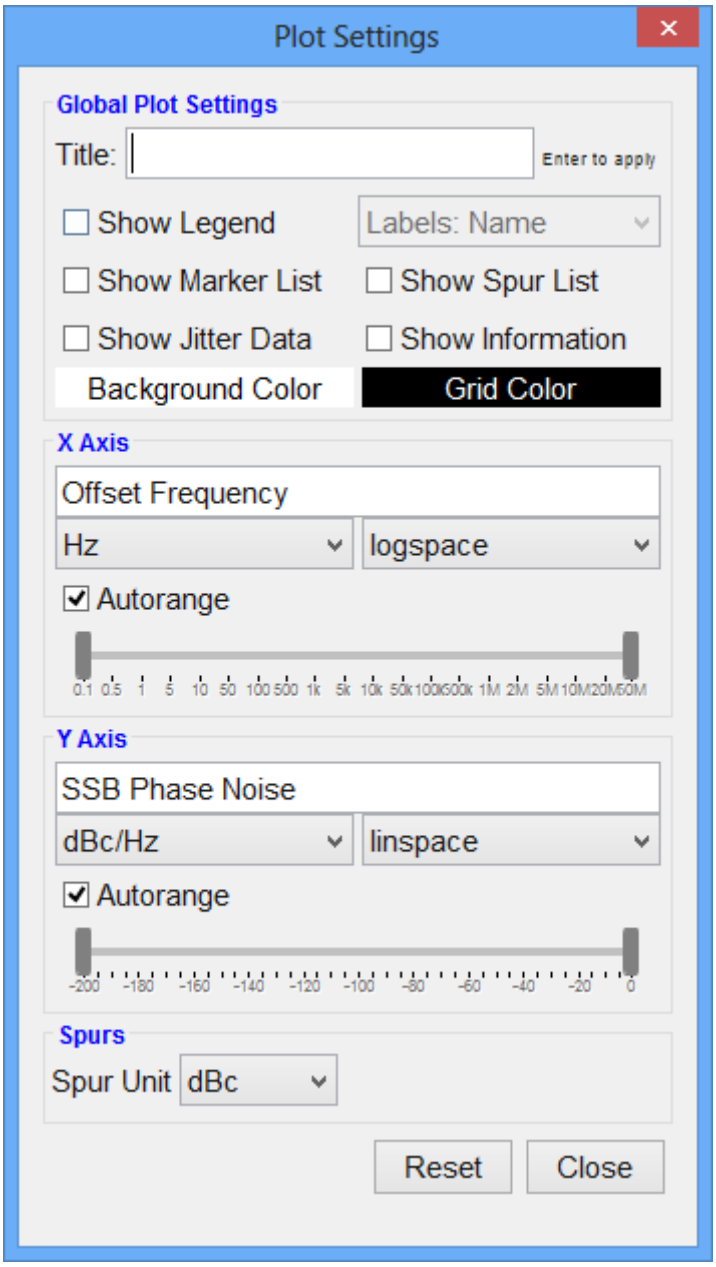
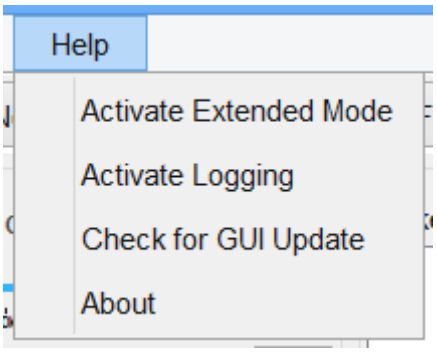


Figure 5 Spec Line Dialog Window

Plot → Settings opens the Plot Configuration Settings window as shown below. The plot configuration window allows customizing the plot window. Window title, marker lists, or trace data information such as residual FM or PM or integral Phase Noise can be displayed by checking the corresponding box. The appearance of the plot can be changed as well. In the middle section, the x and y axes can be scaled and renamed. The lower section “New Plots” contains the default settings for newly created plots. To change already existing plots, edit them directly in the plot list. With “Show Spurious” on, detected spurious can be displayed with a user specified threshold. Only spurious signals above the user set level will be displayed. The “Smoothing Aperture” setting can be used to video average the traces over a user set bandwidth.



View → Toggle Fullscreen allows toggling from and to full screen mode.

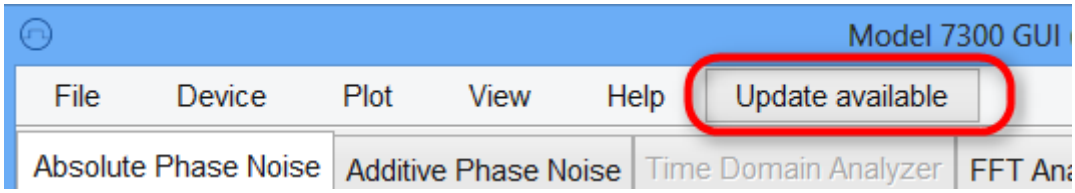


Help → Activate Extended Mode is intended for Berkeley Nucleonics engineers only and is used to calibrate the devices. **Currently, customers can not activate this option.**

Help → Activate Logging logs status and error information from the GUI into a binary file. This file can then be sent as part of an error report to the Berkeley Nucleonics support email hotline. This should not be activated during normal use as the logging slows down the application which can affect the user experience.

Help → Check for GUI Update can be used to verify, if a newer version of the GUI is available for download from the Berkeley Nucleonics website. If a new version is available, it can be downloaded and installed directly.

Help → About displays the GUI version information.



Update button If the GUI has internet access, it will check for new versions on startup. If there is a new version available, the GUI will notify you by displaying an update button on the right side of the menu. Click it to start the update procedure.

3.3 Measurement Tabs

The following tabs (each corresponding to a particular measurement mode), are available:

- Absolute Phase Noise,
- Additive Phase Noise, Amplitude Noise (SERIES 7000 only),
- Time Domain Analyzer (MODEL 7300 and MODEL 7070 only),
- FFT Analyzer.

Clicking on a tab will lead to the corresponding measurement setup. The following sections describe each measurement tab and how to configure it to successfully perform a measurement.

3.3.1 General Tab Organization

In general, each measurement tab is organized in two sections, a SETUP and a PLOT section.

The SETUP section in the upper left corner is used to configure a particular measurement.

The PLOT section is used to display and post-process measured data. This section can be further sub-divided in a Marker, and Trace and a Display window.

3.4 Phase Noise Measurement Tab

In this tab the DUT's signal frequency and power is detected and the phase noise of the signal in the specified offset frequency range is analyzed. The measurement principle is based on the phase discriminator method in combination with a two channel cross-correlation. In general, two internal or external low noise reference sources are phase locked to the DUT signal. The frequency of the DUT is detected and a well characterized phase locked loop is closed. Each receiver channel now converts phase fluctuations between DUT and reference source into low frequency voltage signal by means of a calibrated phase detector. Inside the PLL bandwidth, the phase differences are suppressed and must be recovered. The two independent measurement channels are fed into FFT analyzers and cross-correlator engine to suppress reference and receiver channel noise and to extract DUT phase noise.

3.4.1 Measurement setup

The following section describes the basic setup procedure to perform the measurement within the phase noise measurement tab. With just a few configuration steps, the phase noise measurement can be performed.

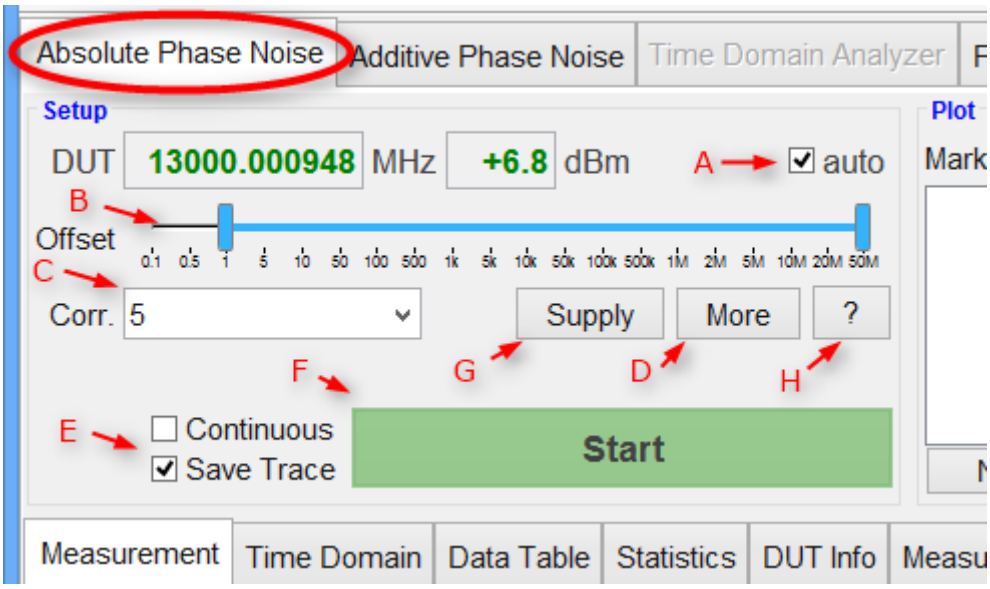


Figure 6 Setup section of absolute phase noise tab

A) Enable internal frequency counter and power meter (see Figure **6**): If the search button is enabled, the counter and power meter are running and constantly updating the detected DUT frequency and power. Disabling allows manual entry of the DUT frequency. Internal counters and power detector is shut down. Per default, the auto-detection is on and once a valid signal is detected, the measure button turns green and is enabled.

B) **Set frequency offset range using slider.** The frequency offset can be set freely from 0.1 Hz up to 50 MHz (1 MHz for SERIES 7000/SERIES 7000).

C) **Select the number of correlations/averages**: The number of correlations and averages can be set by clicking on this button. This will open up a dialog that allows the user to set the parameters to predefined values using the drop down menu. It also allows for other values by simply typing them in.

D) **Use the reference button to select between internal and external reference sources.** By default, the internal sources are used and no additional configuration is needed. See the "Using external references" section for more information about how to use external references.

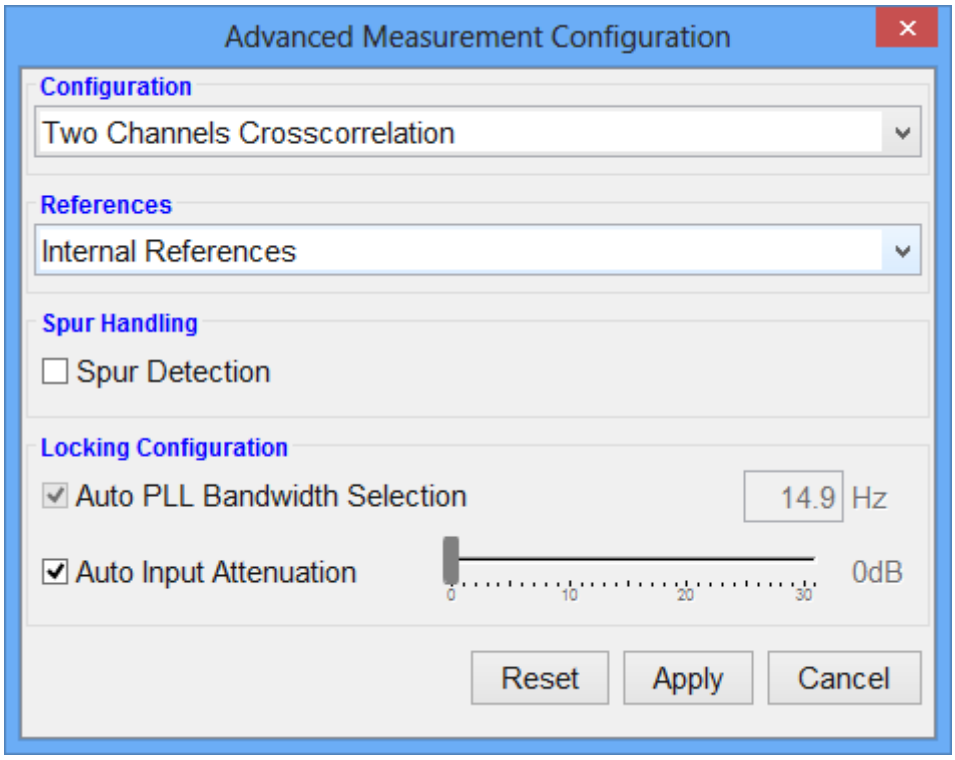


Figure 7 "More" Configuration Menu allows choosing reference source

E) **Configure Continuous & Save Trace Options:** With "Continuous" is enabled, the measurement is restarted automatically after completing the selected number of correlations.

With "Save Trace" enabled, the trace of a completed measurement is automatically imported and stored in the Trace List.

F) **Click Measure Button:** Once the Measure Button becomes green, a new measurement can be started. Click on the button to start the measurement and click again to stop the measurement before completion.

G) **Configure Supply *(option SUPPLY only)*:** If available with the currently connected device, this button will open the supply dialog in which the output voltage on the two supply channels on the back panel can be configured (as shown in Figure 8). The supplies can be separately set, enabled/disabled and the current is measured continuously while this dialog is open. Depending on the reference setup, the external tune ports can be configured to output a constant voltage. This can be used for example as bias voltage for oscillators.

H) **Connection Diagram:** Clicking on the button with the question mark will open a connection diagram that represents the currently selected measurement setup. For a basic phase noise measurement, this diagram is very simple, but it can be helpful for more difficult measurement setups (like a two channel external references measurement or an additive phase noise measurement).

After clicking on the Measure button, the phase noise measurement is started. A couple of calibration steps are automatically performed and phase noise data is acquired from SERIES 7000. In the Measurement tab of the plot window the red trace shows the intermediate result as shown in Figure 10.

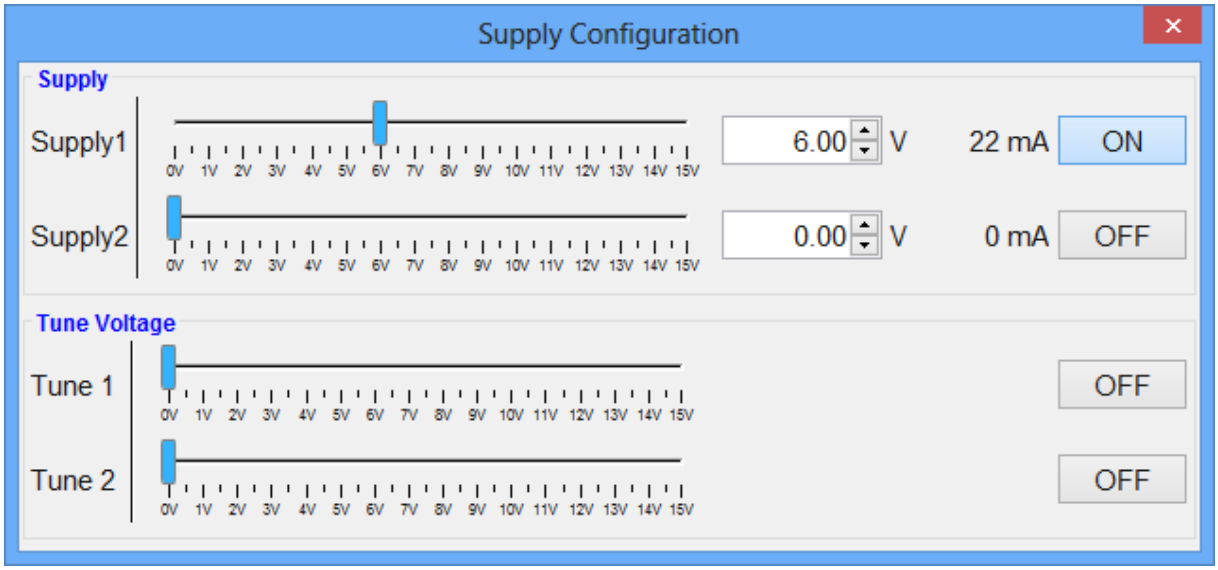


Figure 8 Supply dialog with the first channel enabled.

Once the measurement is completed, the GUI returns into idle state. During the idle state, the "beat" signal of the two measurement channels can be observed in the "Time Domain" tab of the measurement window as shown in Figure 9.

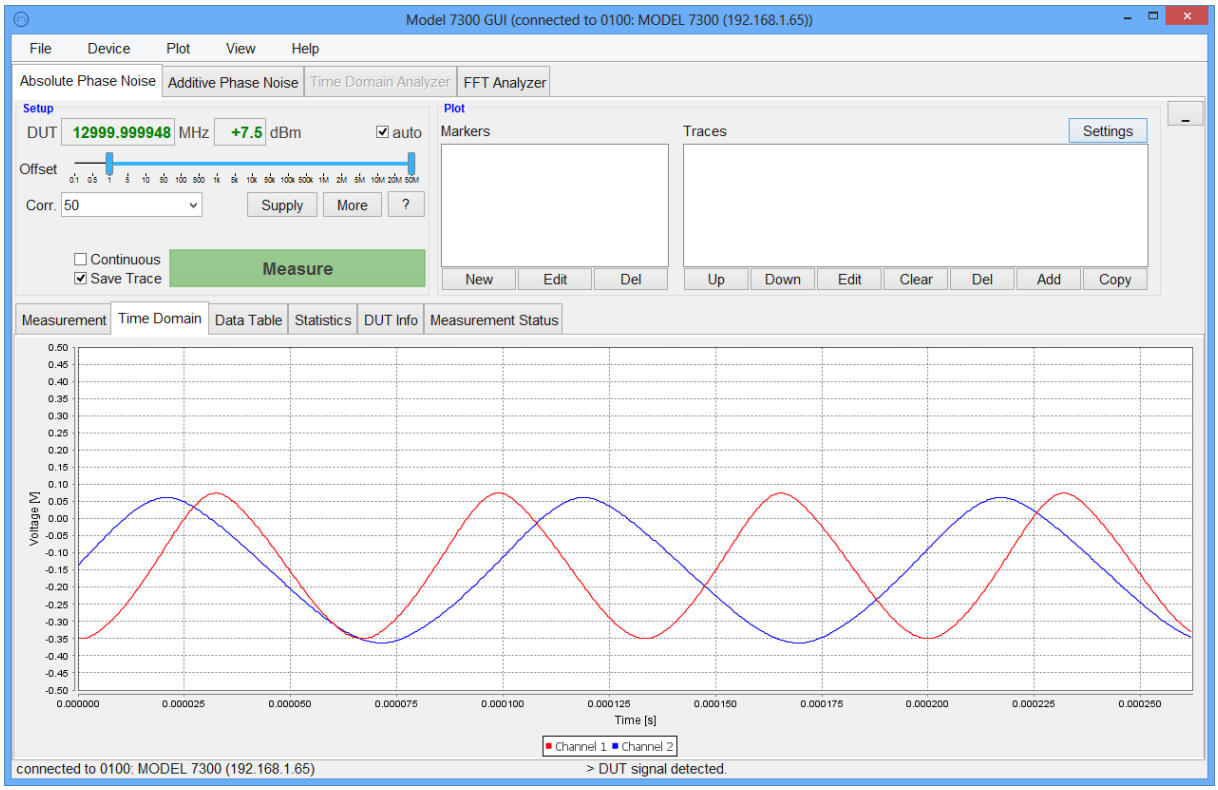


Figure 9 Beat frequency as shown in the time tab within the plot window.

Upon measurement start the SERIES 7000 will adjust the input step attenuator to avoid power compression and maximize dynamic range, calibrate the phase detector and phase lock the internal references. The “Measurement Status” tab will indicate measurement progress and provide status and error messages..

The loop bandwidth is adaptively set to ensure stable and reproducible measurements with maximum dynamic range. The gain of the IF amplifiers is adjusted to measure at lowest sensitivity without driving the stages into compression.

Note that the measurement time needed largely depends on the offset range measured and the total number of correlations.

Figure 10 shows a screenshot of the GUI after a completed measurement. Below the actual (red) measurement trace, a gray polygon (shade trace) is visible. This polygon indicates the measurement floor for the current measurement. With increasing number of correlation, this noise floor will decrease. If the measurement trace at a given offset is above the noise floor the measured trace has reached a steady-state value at the same offset. Increasing number of correlation will only “smooth” the curve and remove trace noise, but will not further improve the phase noise value.

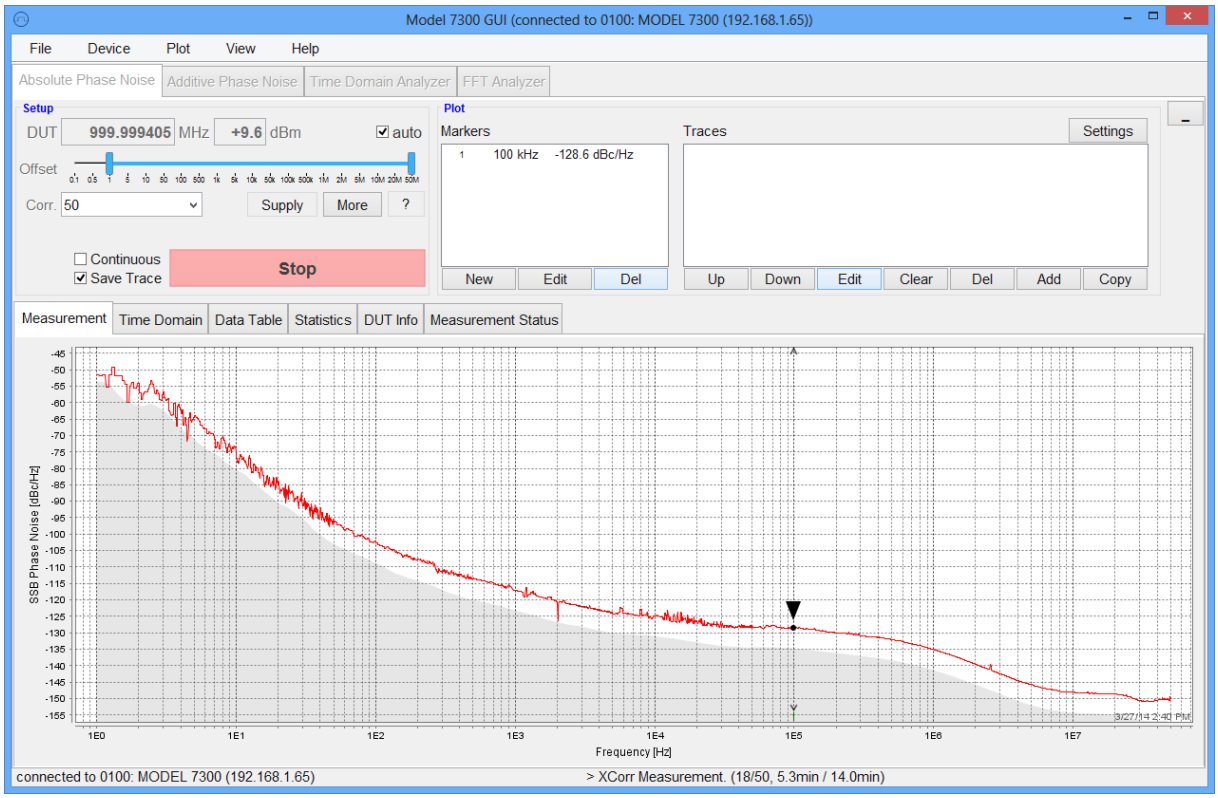


Figure 10 Phase noise measurement completed. Noise floor (grey shade) is clearly below measured trace (red).

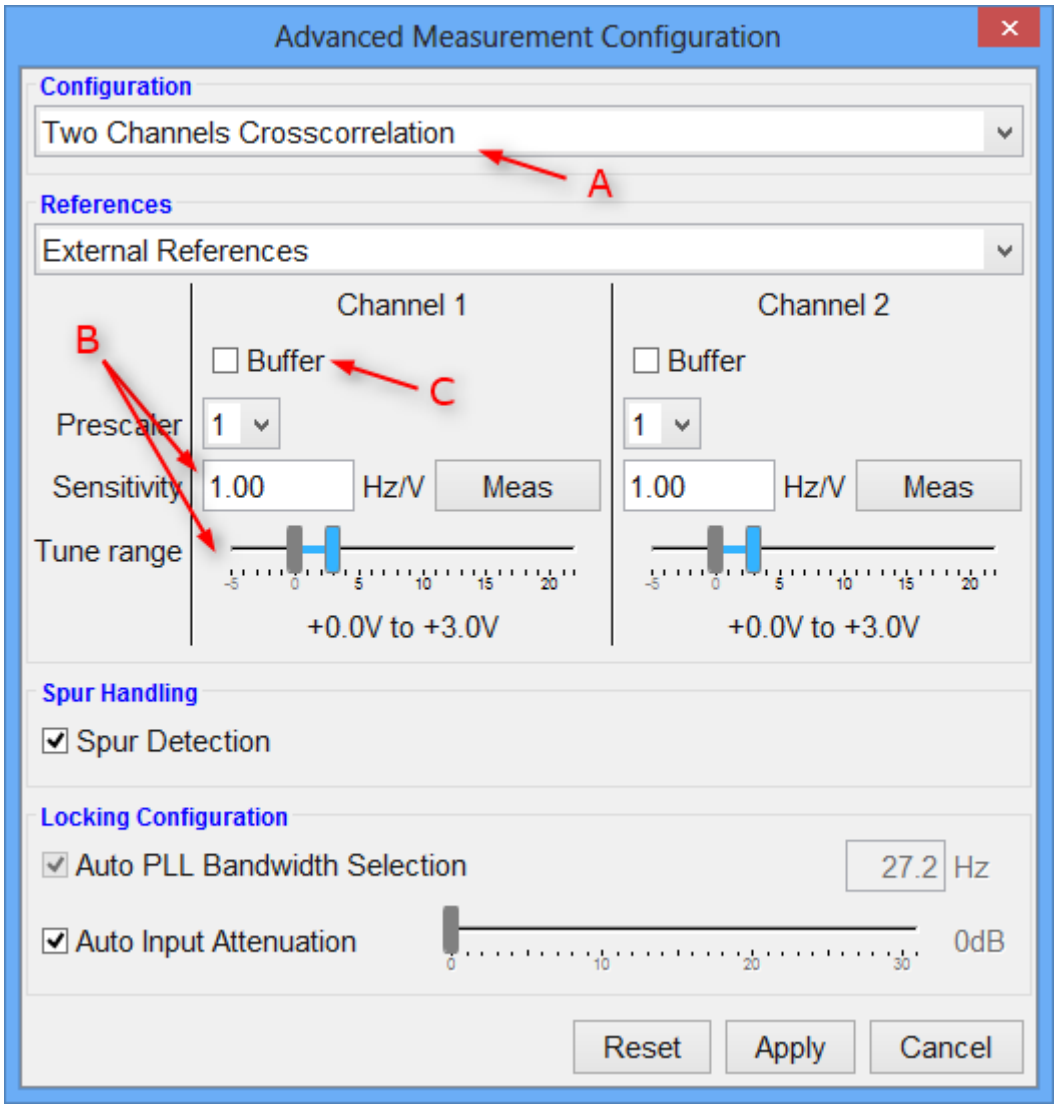
3.4.2 Using External References

Configuring external references requires some additional parameter settings.

A) Select between one channel or two channel measurement.

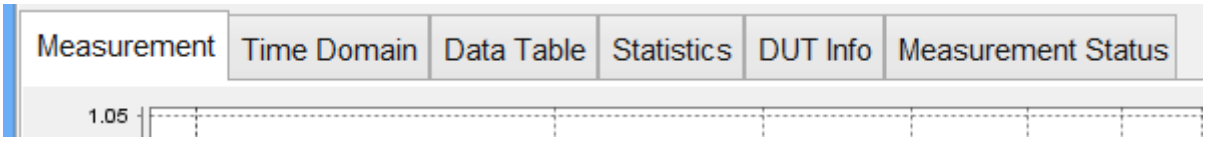
B) Enter tuning slope (Hz/V) for each measurement channel used. Also enter the tuning voltage range for each reference. Using the “Meas” button, the tuning slope can also be measured automatically.

C) If your reference source does not provide sufficient output power, you can also use internal buffer amplifiers by clicking the “Buffer” checkbox. The buffer amplifier provides about 10 dB gain with a noise figure of 2 dB.



3.4.3 The Different Plot Window Tabs

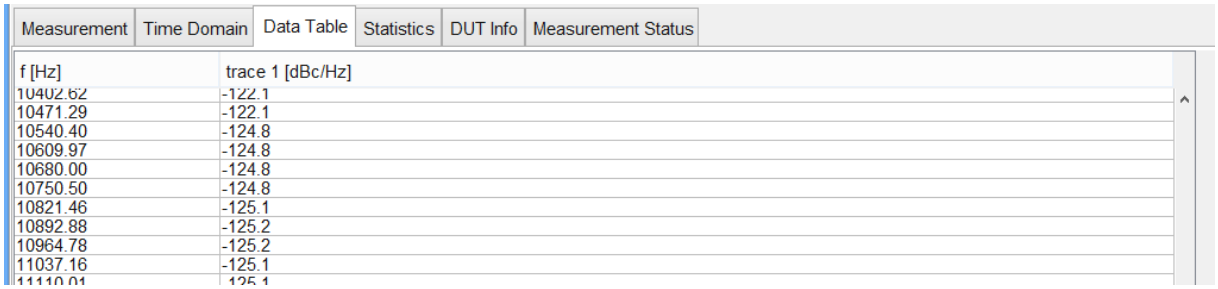
The plot window comprises of six tabs – Measurement – Time Domain – Data Table – Statistics – DUT Info – Measurement Status:



The Measurement tab **is the main tab to display frequency domain results like phase noise.**

The **Time Domain tab** is used to provide time domain measurement information during idle state (frequency and power detection, calibration) and during the measurement process (locking, and data acquisition). During the actual measurement, samples of the noise voltage are also displayed in this window.

The **Data Table tab** displays the noise measurement data for selected traces as data table. This table can also be exported to a file (in different formats) with **Plot → Save**



The **Statistics tab** (as shown in Figure 11) provides additional statistical information such as integrated RMS jitter, integral phase noise, residual FM and PM as well as Allan deviation and a RMS jitter figure that plots RMS jitter vs offset frequency.
After each correlation the latest measurement is updated in the plot window. The statistic tab displays the information for the currently selected trace, or if none selected, for the first trace in the trace list.

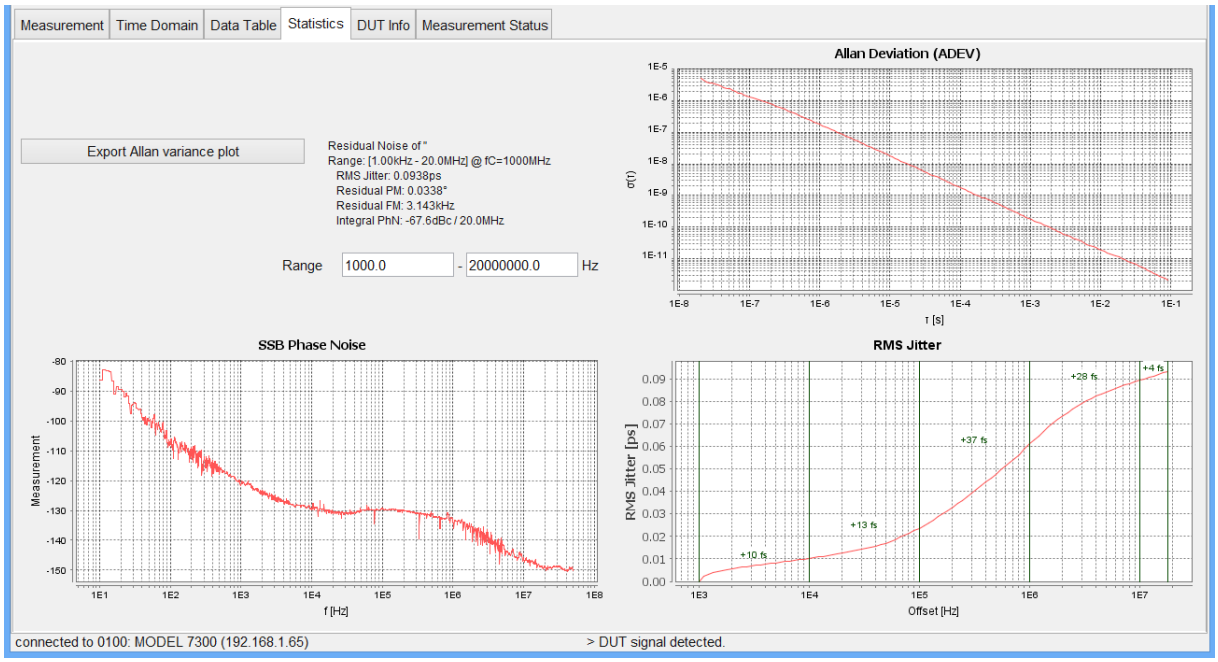


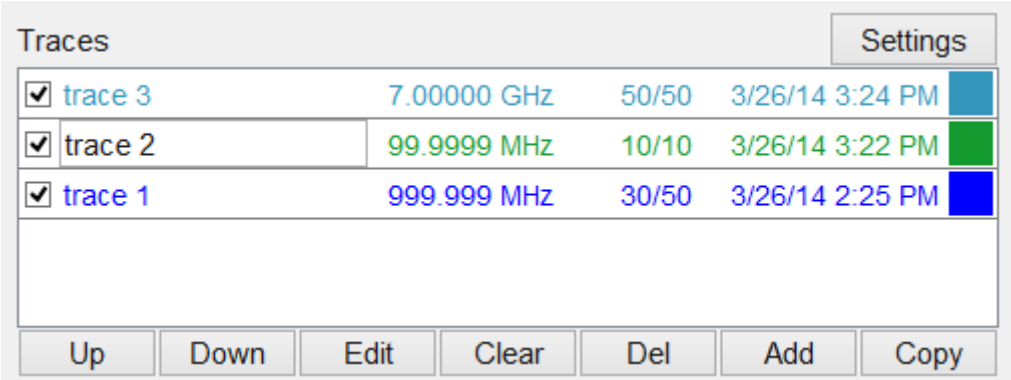
Figure 11 The statistic tab provides additional information about the selected data trace

The **DUT Info tab** constantly monitors the DUT CW frequency and power and also shows the tuning voltage of internal references. The values are updated approx. once per second in GUI idle state.

The **Measurement Status tab** prints status and error messages that help user to verify the measurement process.

3.4.4 The Traces Window

The Traces window is used to save and post-process acquired traces. The different functions can be accessed from the buttons located below the Traces window as shown below.



3.4.4.1 Add button

Copies of the actual measurement trace (red trace) can be created and stored in the trace list by clicking on the “add” button.

A copy of the active trace is stored in the list and by default named with “trace 1” with additional information such as DUT frequency, number of correlations and time and date of measurement.

Each trace can be renamed by double-clicking on the corresponding trace name and typing in the new trace name.

3.4.4.2 Copy button

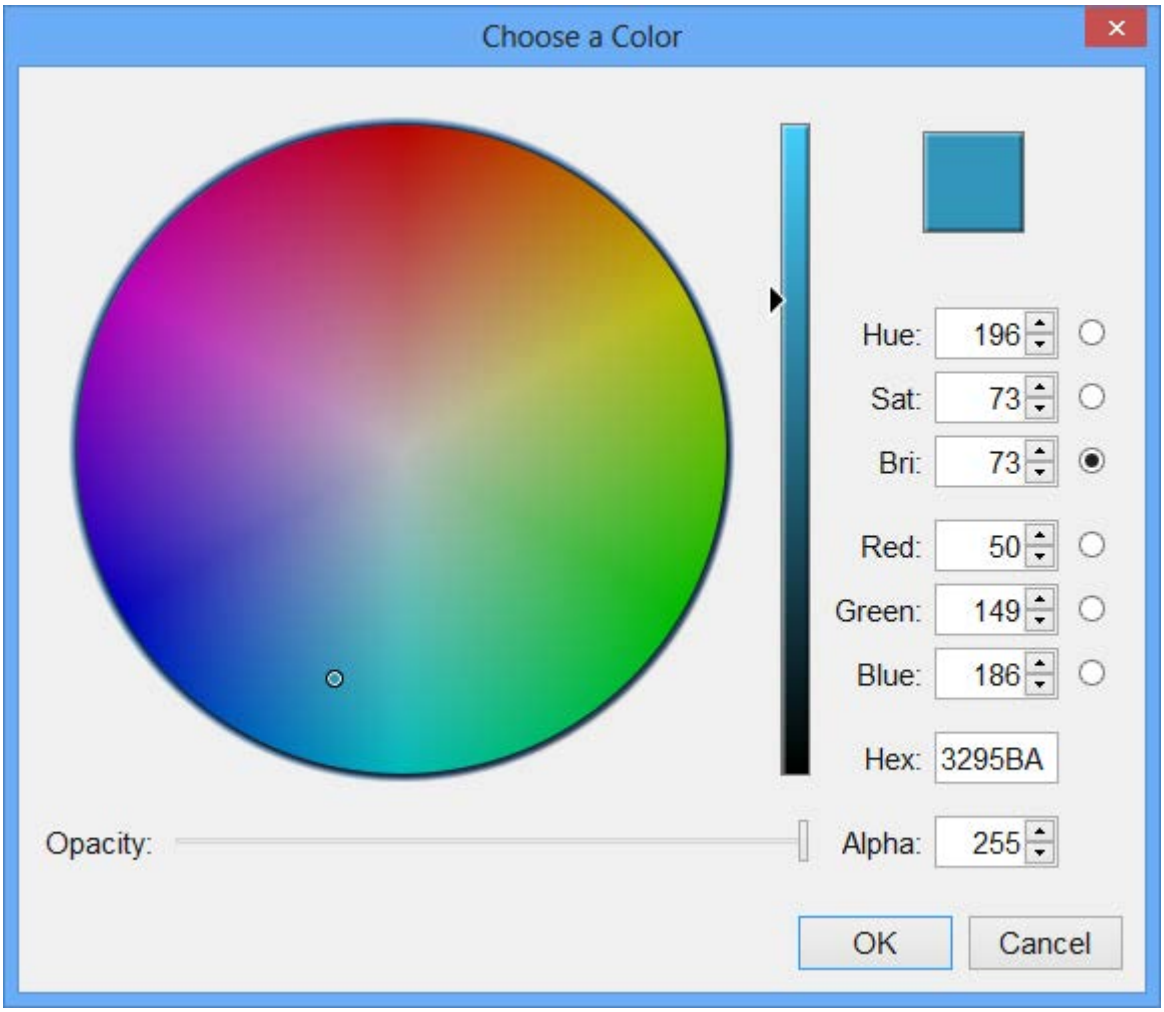
Using the “copy” button, identical copies of the selected traces are generated.

3.4.4.3 Up and Down buttons

Individual traces can be moved up and down by pressing “Up” and “Down” buttons, respectively. The ordering of the traces in the list affects the order in which they are drawn in the plot.

3.4.4.4 Modify color of traces

Individual trace colors can be assigned to traces by clicking on the color box on the right and selecting the desired color from the color dialog. Traces stored in the list can be made invisible in the current plot window by un-checking the checkbox in the left.



3.4.4.5 Selecting and unselecting traces (Clear button)

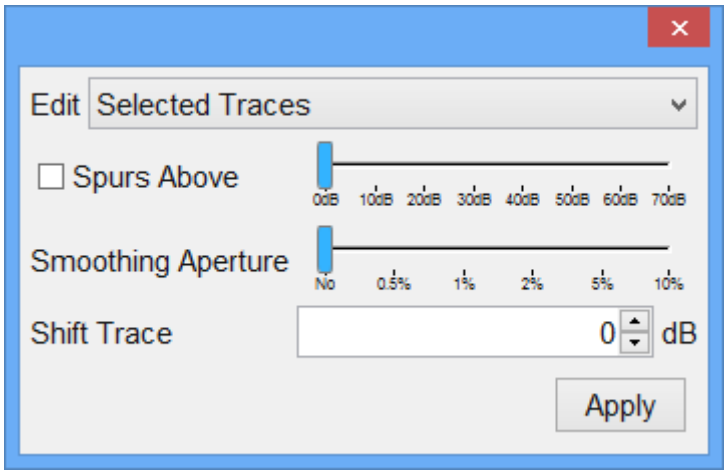
A single click will select a trace. The selected trace will be drawn as thick line. Multiple traces can be selected with holding “Ctrl” and all traces become unselected by clicking on the “Clear” button.

3.4.4.6 Delete traces

Selected can be removed from the trace list by clicking on “Del” button.

3.4.4.7 Edit button

Selected traces can be edited with “Edit” button that opens a window as show below.



In this window, first choose to which traces the changes shall be applied: selected traces only, all stored traces, or all newly measured traces.

The following functions can be applied:

1. Completely remove or show detected spurious signals that are above a user set threshold.
2. Apply video averaging (smoothing) to the trace with user set aperture.
3. Shift trace by a user specified number of decibels (up or down).

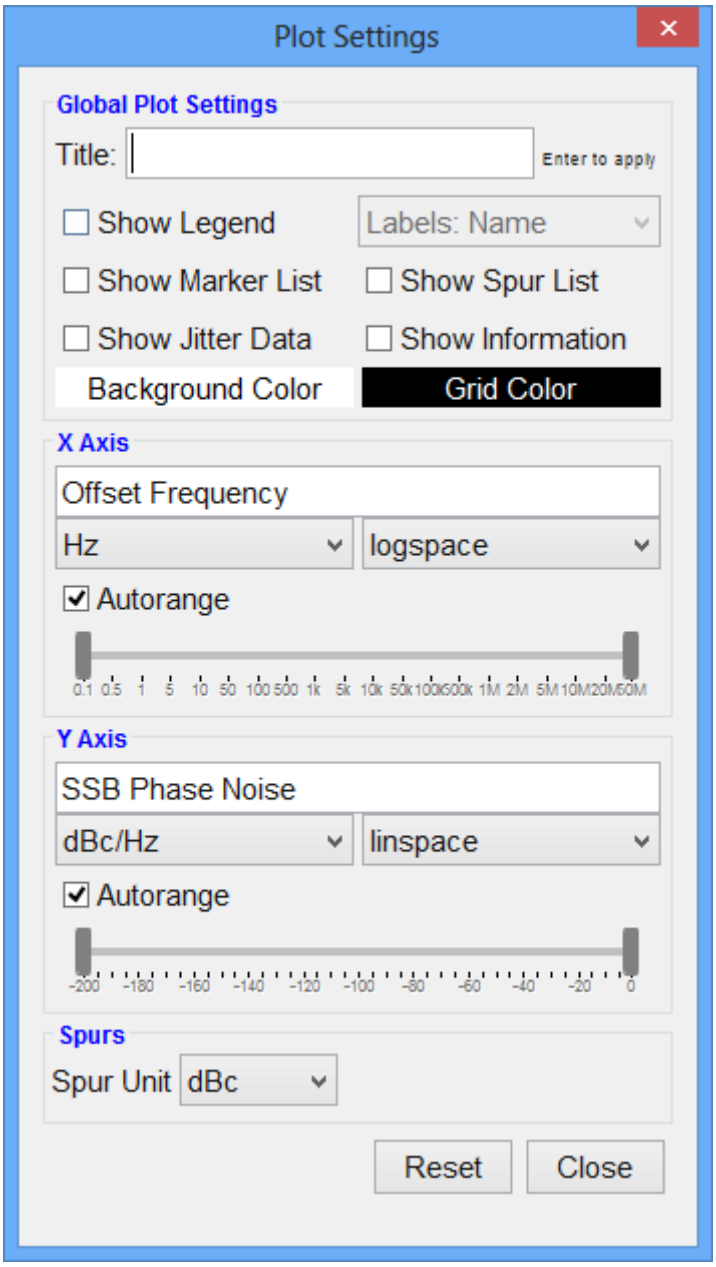
Changes are immediately applied to the traces. The “Apply” button just confirms and closes the window.

3.4.4.8 Settings button

With the “Settings” button, the plot configuration window is opened as shown below. In this window, the following general plot settings can be changed:

1. Assign a Title to the plot
2. Visualize Legend, Spur List, DUT Information, Marker List, or Jitter Data window
3. Change plot window background and grid color
4. Modify X and Y scales, labels, and units.
5. Modify Spur unit

Changes are immediately applied to the traces. The “Reset” button allows resetting to default values.



If enabled, Spur and Marker Lists, the RMS Jitter, Residual phase error, the residual FM and the integral phase noise are displayed for the selected trace in small windows inside the measurement window and offset range as shown in Figure 12.

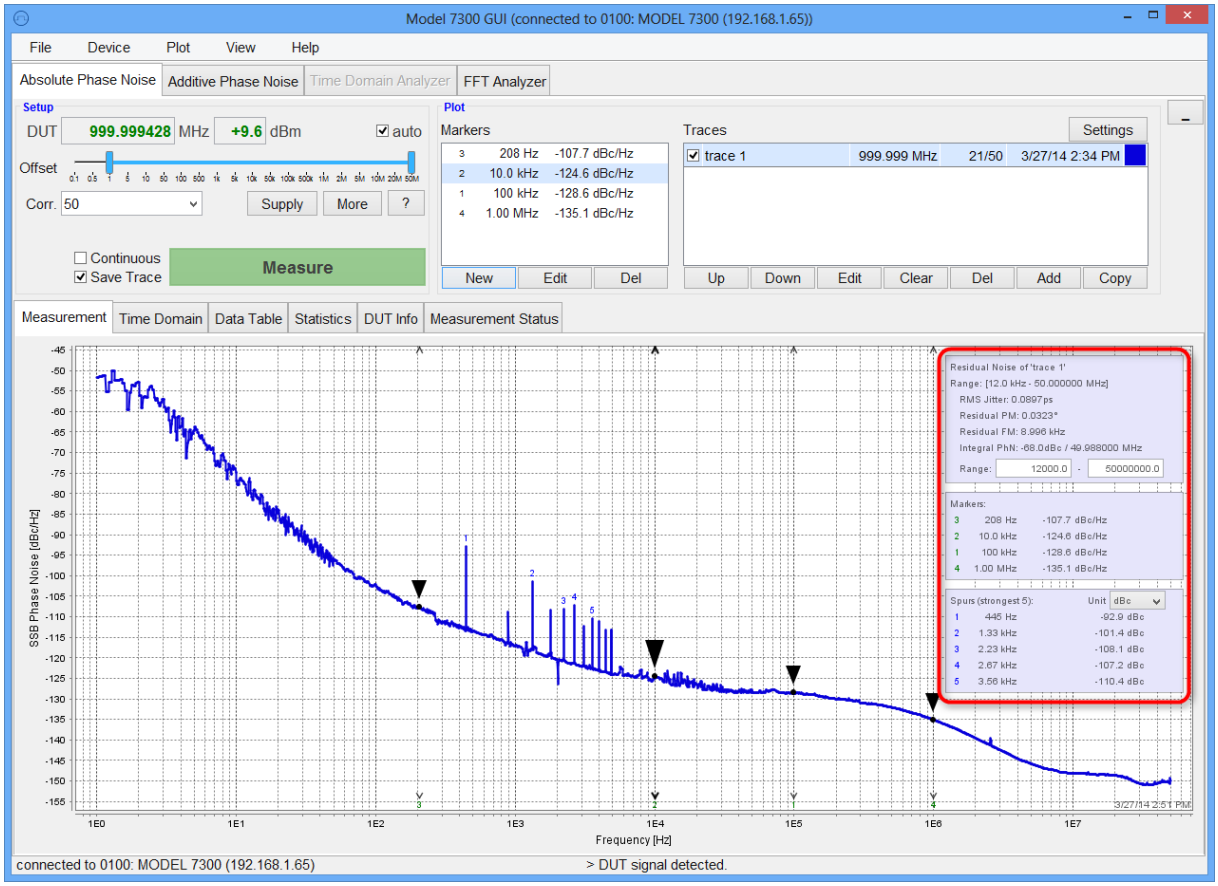
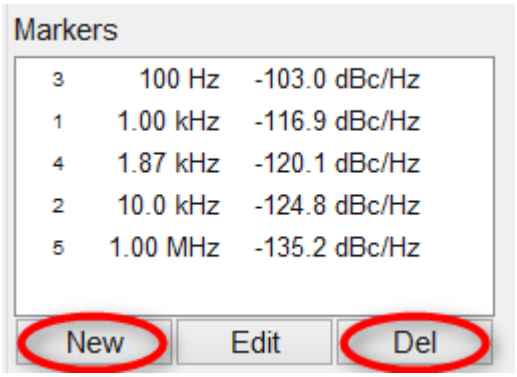


Figure 12 Plot window with Residual Noise and Marker Lists displayed

3.4.5 The Marker Window

Multiple noise markers can be applied within the plot window. To add a new marker, press on the "New" button as shown below and move the mouse within the plot window.



The marker will follow the active or selected trace. You can move markers to the desired trace by selecting the corresponding trace in the trace list.

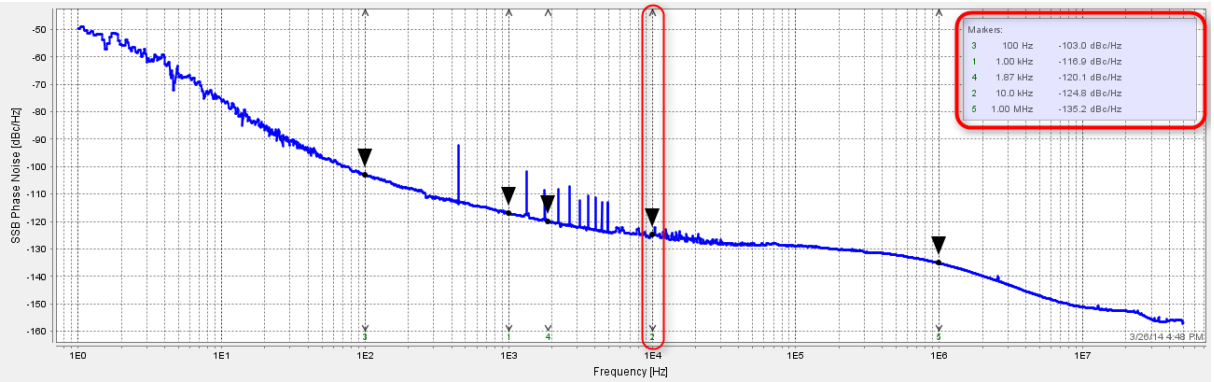


Figure 13 Plot window with single trace selected and displayed and multiple markers set

3.4.5.1 New Markers

After clicking the "New" button, marker mode is activated. In this mode, a marker will follow your cursor in the plot. The marker can be set with a single left click. The marker will then appear in the marker list and the marker mode is deactivated again. The marker mode can also be left by pressing Escape on your keyboard. Once a marker is placed, it can be moved and the corresponding phase noise value is displayed in the window as shown in Figure 13.

3.4.5.2 Editing and Deleting Markers

Markers can be removed by selecting them in the Markers list and clicking on the “Remove” button. A selected marker can be set on precise offset frequency by clicking on “Edit” button and entering the desired value by keyboard.

3.4.5.3 Moving Markers with the Mouse

Within the plot window, the user can move markers by clicking and draging the marker horizontally. The marker can be clicked on at any vertical point at the exact horizontal position of the marker.

3.4.6 Inside Plot Window Functions

Within the plot window, you can

i. move markers around by clicking on a set marker and dragging it to a different position.
ii. zoom in by clicking the mouse in the upper left corner of the zoom window and draw the window desired.
iii. zoom to full by clicking on the plot window and move the mouse to the upper left.
iv. print, save, and copy by right mouse click.

3.4.6.1 Print, Save and Copy Traces

Phase noise plots can be printed by moving the mouse over the plot window and pressing the right mouse button (Figure 14) or through the **Plot → Print** menu.

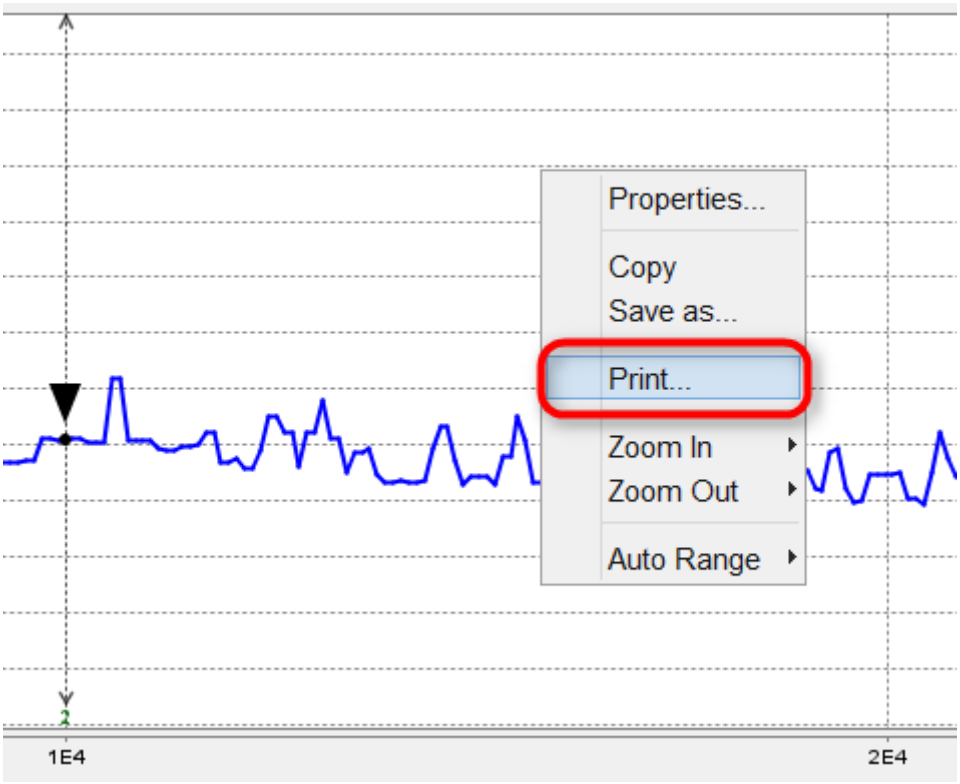


Figure 14 Zoomed in trace

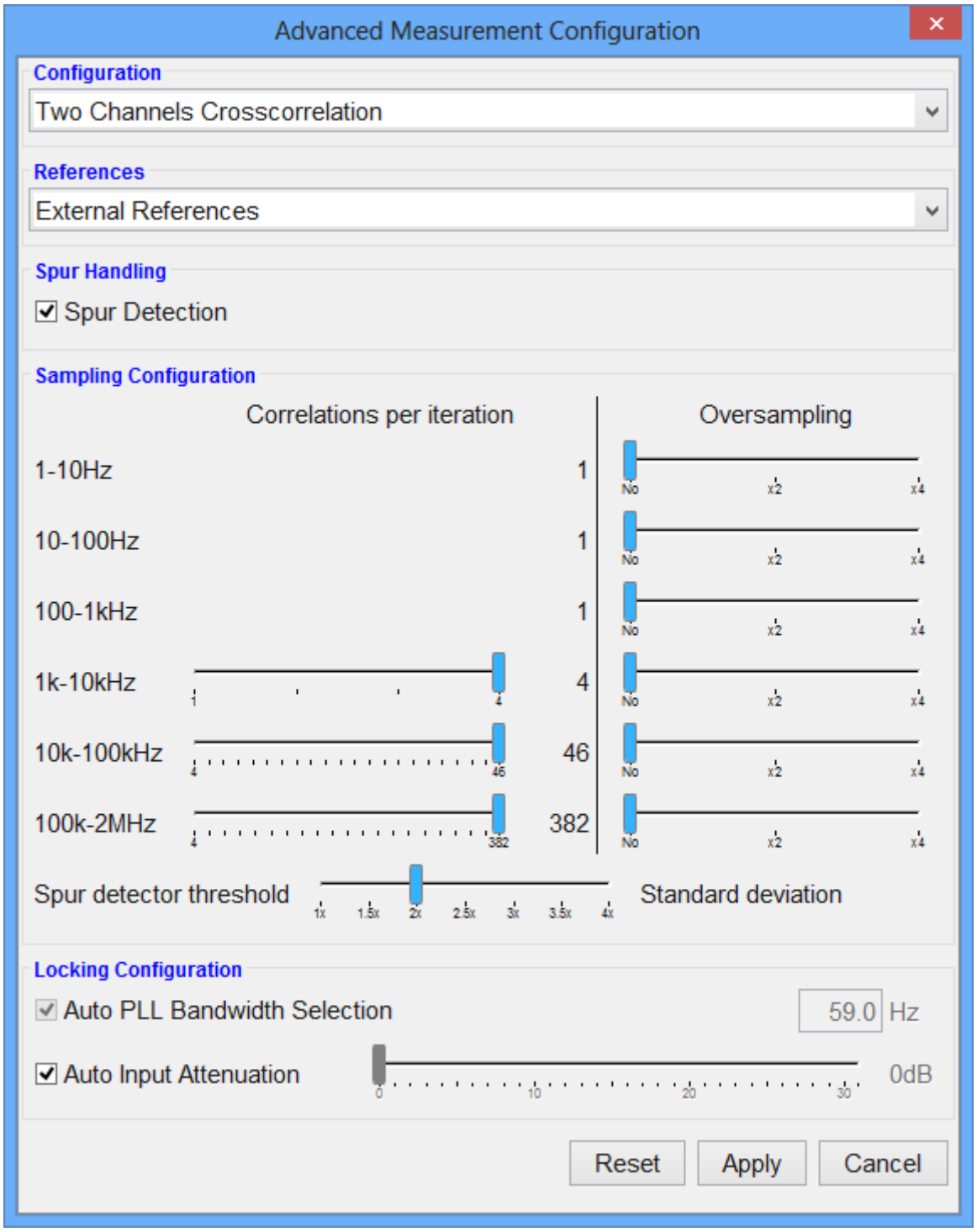
3.4.7 Saving Traces

Traces can be exported and saved in various file formats through the **Plot → Save** menu. The following formats are available:

- ASCII data of the selected trace in CSV format
- Microsoft Excel™
- Matlab™ Data File
- Plot window in PNG format
- All traces in an SERIES 7000 internal format; the internal file format can be loaded into the GUI

3.4.8 Oversampling factor (SERIES 7000 / SERIES 7000 only)

Only for SERIES 7000 and SERIES 7000 systems, the “More” button opens the Advanced Measurement Configuration Window with additional settable parameters as shown below:



Besides programming of the external power supplies, there is a section called “Sampling configuration”. In this section, the oversampling factor can be set. This factor determines the FFT resolution of the measured trace. Per default the oversampling factor is two. The measurement time is directly affected by the oversampling factor. A higher oversampling factor gives better frequency resolution in the FFT and allows analyzing more details of spurious response.
Additionally, individual number of correlations can be set for the measurement decades using the sliders on the left.

3.5 General Measurement Settings

3.5.1 Number of data points per trace

Per default, the number of points displayed in every trace is depending on the start and stop offset frequency. Data for SERIES 7000 / SERIES 7000 and MODEL 7070 /MODEL 7300 are shown in Table 1 and 2.

Start / Stop	10 kHz	100 kHz	1 MHz
0.1 Hz	750	900	1050
1 Hz	600	750	900
10 Hz	450	600	750
100 Hz	300	450	600
1 kHz	150	300	450

Table 1: Displayed number of points per trace (SERIES 7000 / SERIES 7000)

Start / Stop	10 kHz	100 kHz	1 MHz	50 MHz
0.1 Hz	1250	1500	1750	2150
1 Hz	1000	1250	1500	1900
10 Hz	750	1000	1250	1650
100 Hz	500	750	1000	1400
1 kHz	250	500	750	1150

Table 2: Displayed number of points per trace (MODEL 7300 / MODEL 7070)

3.5.2 Measurement time (using GUI)

The measurement time required by the SERIES 7000 is depending on several parameters. The total measurement time consists of a setup time, sampling time, and post-processing time.

3.5.2.1 The Setup Time

The setup time largely depends on the user settings and reference sources used. Very low noise sources tend to have a small tuning sensitivity and behave slowly and with narrow loop bandwidths the locking process takes increasingly more time.

The setup time depends on the user configuration and measurement frequency and consists mainly on performing calibration steps and acquiring phase lock on the references sources.

The sampling time depends on the selected frequency offset range and the number of samples taken (oversampling factor, RBW). With increasing RBW the ability to distinguish spurious in frequency gets lost, but sampling time decreases. The number of measurement points per trace varies depending on the selected oversampling factor.

The post-processing time is used to post-process and visualize the measured data. While this portion may be considerable for the SERIES 7000 and SERIES 7000, it can be almost neglected for the other systems. The post-processing time depends on the computer performance, on which the remote client software is running and the interface between SERIES 7000 and PC. LAN is generally faster than USB.

The typical measurement times per average/correlation (includes sampling and post-processing time, oversampling factor=1) is shown in Table 3.

Start Frequency (Hz)	Measurement Time (sec) SERIES 7000 / 30G	Measurement Time (sec) MODEL 7070 / 20G
0.1 Hz	120	130
1 Hz	20	14
10 Hz	3.5	1.7
100 Hz	3	1.2
1 kHz	2.2	1.1
10 kHz	2.0	1.0

Table 3: Typical measurement time (sec) for SERIES 7000

3.6 Additive Phase Noise Measurement

The additive phase noise measurement tab provides single- or two channel cross-correlation additive phase noise measurements on non self-oscillating devices such as amplifiers in linear and non-linear operation or even frequency-translating devices such as mixers, frequency multipliers or dividers.

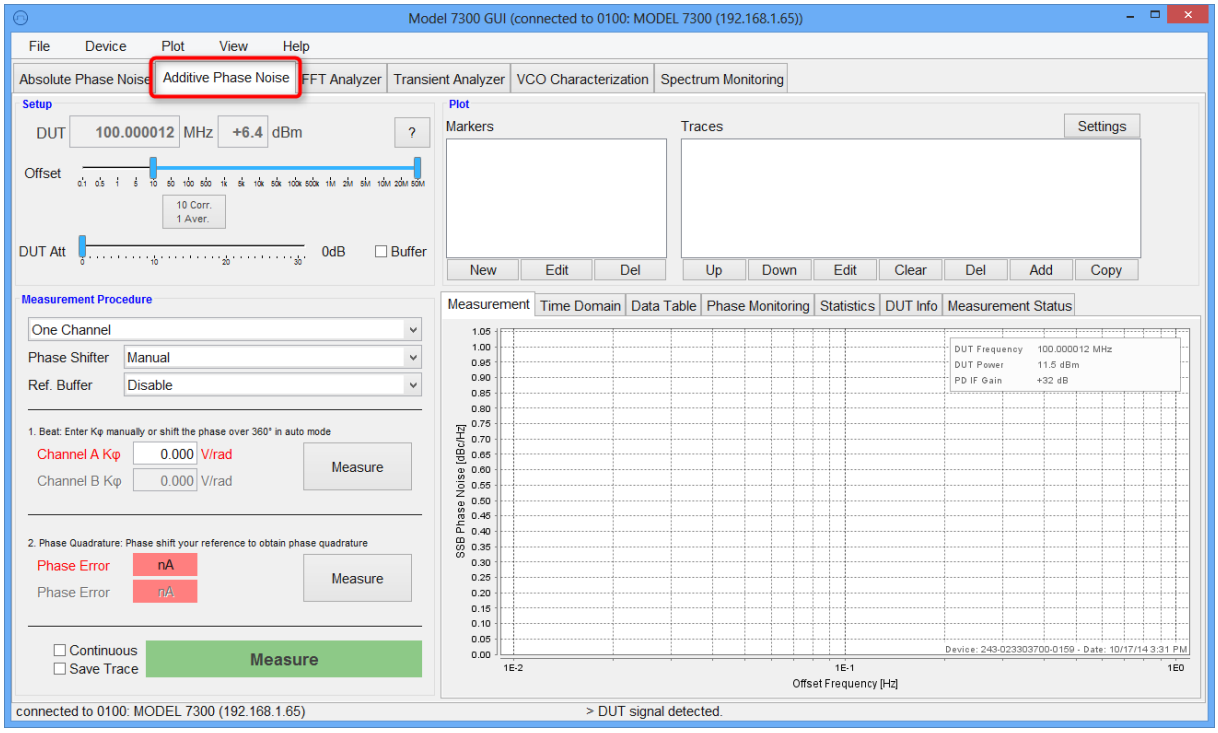


Figure 15 Empty additive phase noise measurement tab

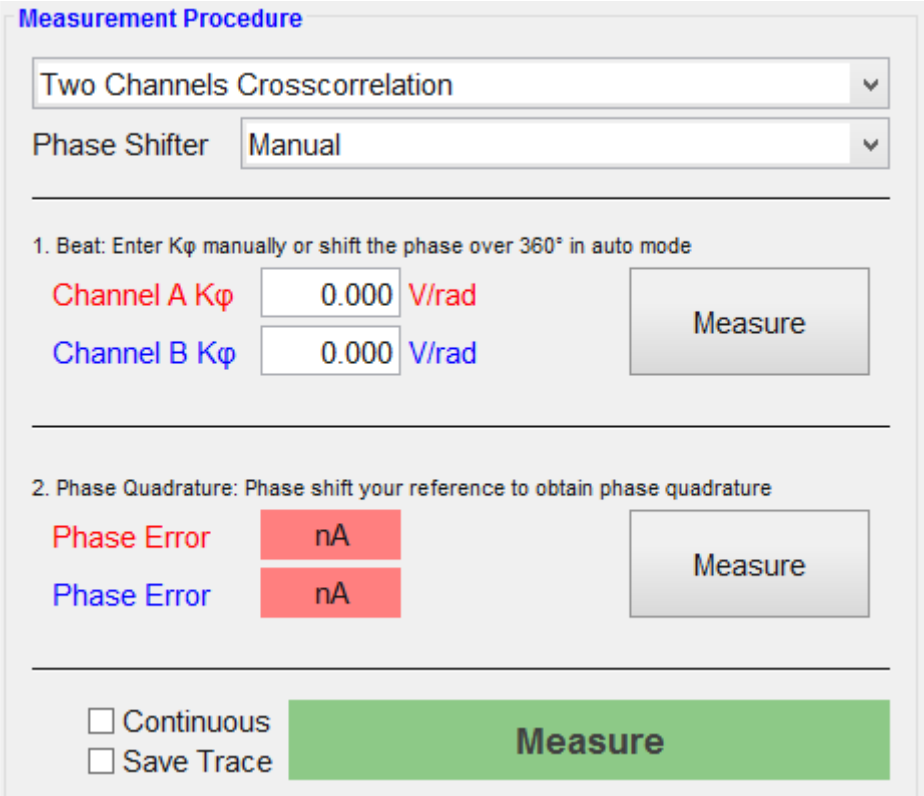
The measurement principle is based on the assumption that the phase noise of the stimulating signal of the DUT (external reference source) is completely cancelled out when manually adjusted to phase quadrature. For the measurement setup, an external phase shifter and power splitter is required for each measurement channel. A suitable external low-noise reference source (stimulus) must be used.

After switching into the corresponding tab, the GUI appears as shown in Figure 15.

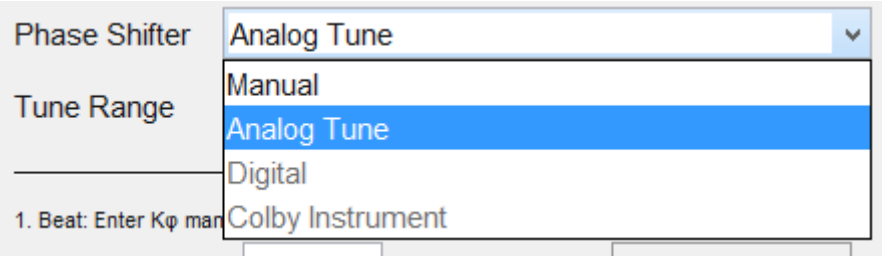
3.6.1 Measurement Procedure

Before starting the calibration and measurement procedure, some parameters must be configured. Firstly, select single or two-channel measurement.

Next, select what kind of external phase shifter is deployed. Any phase shifter is suitable that does not excessively contribute own noise such as digital or mechanically tuned models. Models that are tuned via analog voltage can be supported by the SERIES 7000 GUI.



You should make sure that the drive level at both the reference inputs as well as the DUT input are high enough (i.e. 10dBm or higher). Usually, this can be achieved with the Oscillator and the measurement setup itself. If that is not possible, the DUT input can be attenuated or buffer amplifier. The reference input can be buffer amplified as well.



The measurement procedure to perform an additive measurement consists of three steps:

1. Determine the phase detector constant. Start this step by pressing the “Measure” button in step1. Mechanically or digitally tuned phase shifters must be manually adjusted to provide at least 180 degrees phase shift to derive the phase detector constant. If already known for a given setup, the phase detector constant can be manually entered. In case “Analog Tune” is selected and voltage controlled phase shifters are used, this step is performed automatically by the instrument and can be omitted.

2. Once the phase detector constants are known, the phases must be adjusted to obtain phase quadrature. Start this step by pressing the “Measure” button in step 2. Now, the phase difference between signal pairs at RF IN and REF IN (1 and 2) must be adjusted using the external phase shifters to achieve approximate phase quadrature (90 degree phase difference) as shown in Figure 16. The GUI shows a tolerance window of ±3 degrees. In case “Analog Tune” is selected and voltage controlled phase shifters are used, this step is performed automatically by the instrument and can be omitted.

3. Finally, the actual measurement can be started by pressing the green “Measure” button as shown in Figure 17. Measurement can be stopped and restarted without need of performing step 1 and 2 each time.

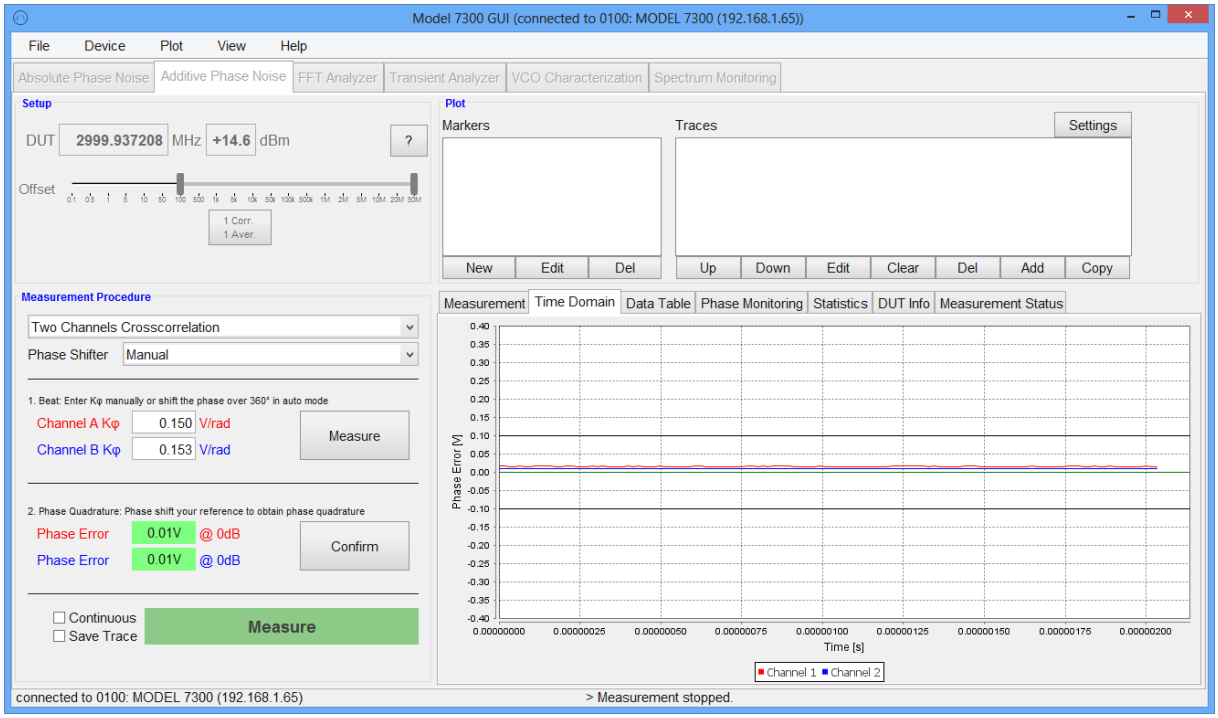


Figure 16 Additive phase noise measurement tab during step 2, adjusting the phase to quadrature.

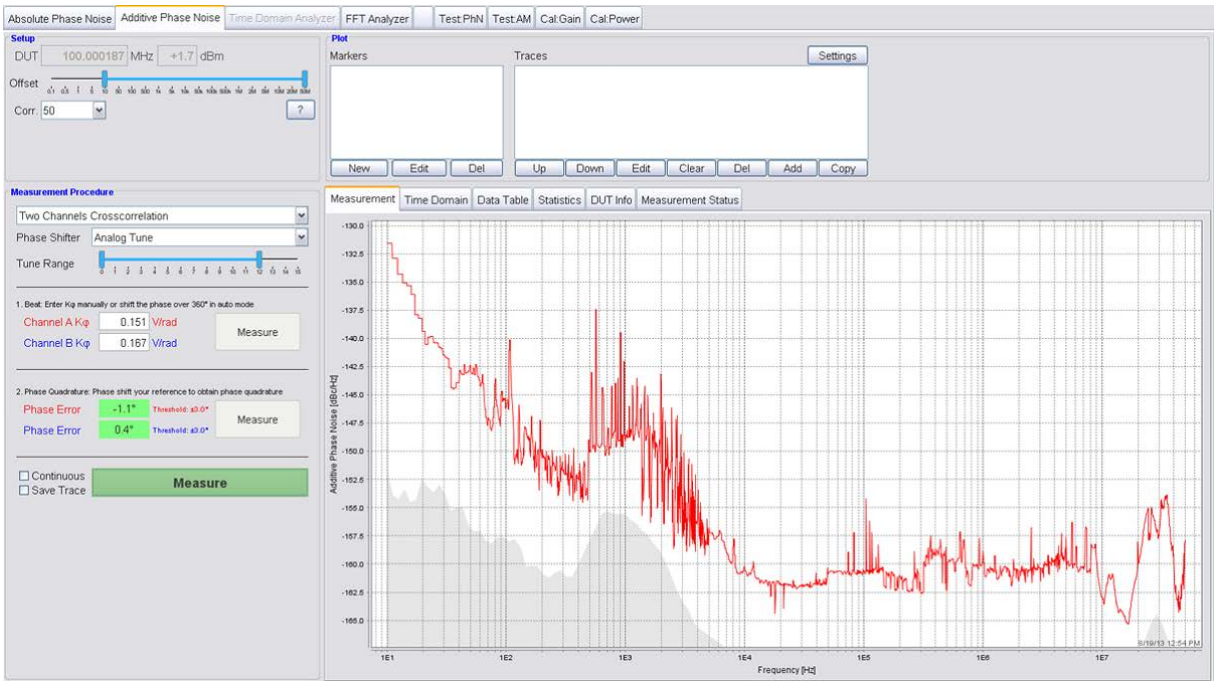


Figure 17 Additive phase noise measurement tab after the measurement completed.

3.7 Transient Analyzer Measurement

The transient analyzer tab provides single- or two channel frequency versus time measurements. The sampling frequency can be chosen up to 62.5MHz, allowing the user to look at fast frequency transients and modulations.

Figure 18 Transient analyzer tab

There are two measurement modes available, wide band and narrow band. The wide band divides the incoming frequency, allowing it to cover a wide frequency range over several Gigahertz. The narrow band mode mixes the input signal with a settable center frequency resulting in a low frequency beat that can be measured with high accuracy and a frequency range up to 40MHz. Both modes can be used simultaneously.

After switching into the corresponding tab, the GUI appears as shown in Figure 18.

3.7.1 Measurement Procedure

Connect your signal to the DUT input connector of the SERIES 7000. Start the measurement in continuous mode by selecting continuous mode in the measurement dropdown (E) and then clicking on the green "Measure" button. The measurement will now continuously run. You can now change the wide band and narrow band settings on the left.

Wide Band Select the approrpiate frequency range (marked A in Figure 18). This will internally select the dividing factor for the signal. Your signal will show up in the wide band plot (the top left plot) and it's frequency distribution will be shown in the bottom left plot. Adjust the measurement settings above the wide band plot by setting the time span of each individual measurement (choosable at G between 10µs and 1hr) and the time resolution (choosable at H between 16ns and 8.6s). Higher values in the time resolution will give you better frequency accurracy at the cost of a lower sampling rate. By default, the wide band plot will be scaled to show the whole selected frequency range. You can also choose to automatically adjust the y axis scaling after every measurement (F), or manually select an area to be shown by drag and dropping your mouse over the desired area in the plot.

Narrow Band For the narrow band measurement, the signal is mixed with an internal signal resulting in a low frequency signal that can be measured without an additional divider. Set the center frequency and the desired span marked B and C. The choosable spans vary depending on the center frequency, as the signal needs to be divided for higher center frequency (limited by the frequency range of the internal source). It can be selected between 10kHz and at least 40MHz and can go up to 300MHz span for signals above 4 GHz. Adjust the measurement settings the same way as described for the wide band parameters in the above paragraph.

Markers You can activate two markers individually by selecting the checkboxes at D. The markers can then be dragged around in the plot. If both markers are enabled, the time and frequency difference is shown in the upper right corner of the corresponding plot (see Figure 19).

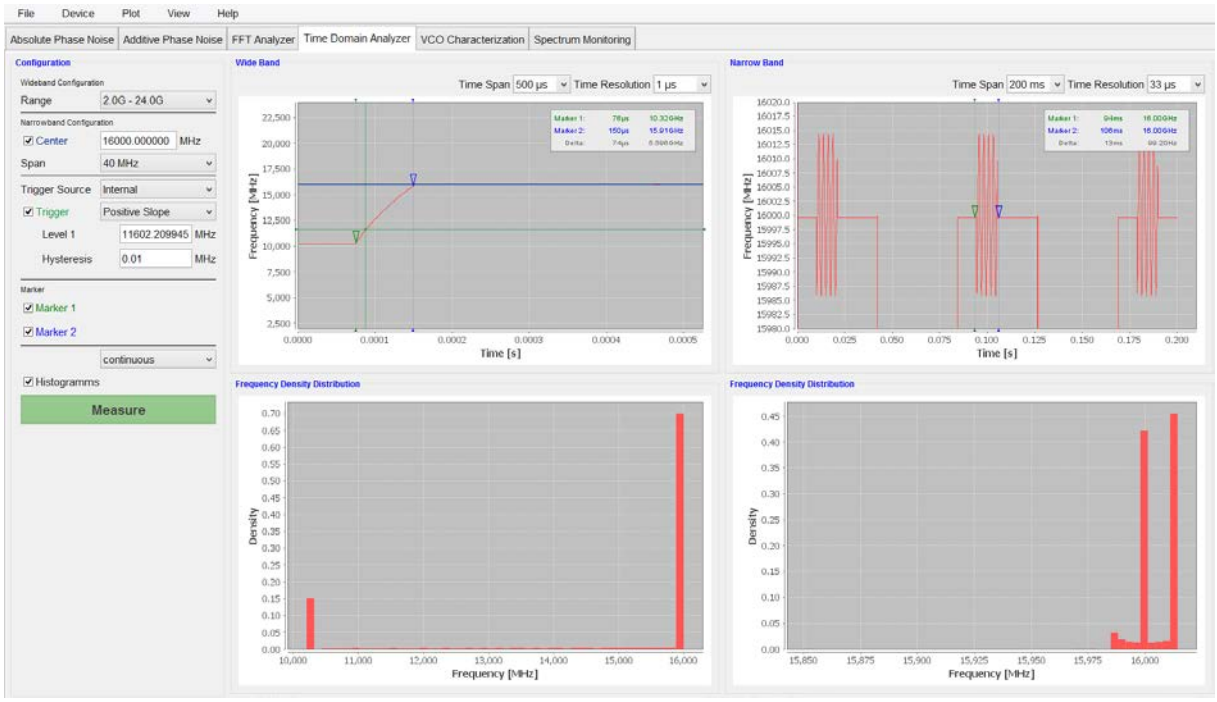


Figure 19 Analysis of a pulse modulated, frequency switching signal.

Trigger System The trigger system allows different trigger modes. To activate the trigger, select trigger source internal (see Figure 20). This will show the trigger configuration in the GUI. Select the checkbox to show the trigger point or line in the wide band plot. Select the trigger type from the drop down menu. Trigger types that can be chosen are:

Positive/Negative Slope triggers when the signal travels through a specific frequency (named Level 1) in a choosable direction (positive or negative).

Entering/Leaving Window triggers when the signal enters or leaves a choosable frequency window defined by two border frequencies (named Level 1 and Level 2).

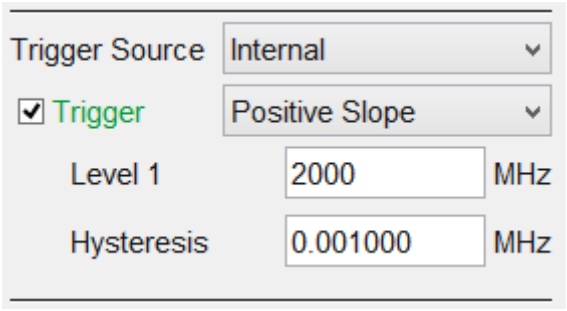


Figure 20 Trigger configuration.

To activate or deactivate the trigger, the current measurement has to be stopped and restarted again after configuring the trigger.

3.8 FFT Analyzer Measurement

This tab is used to measure noise on one or two channels of the FFT analyzer. Select the frequency range and the number of averages. Under “More” select either “Single Channel” or “Two channel cross-correlated” measurement. Press start button to run measurement.

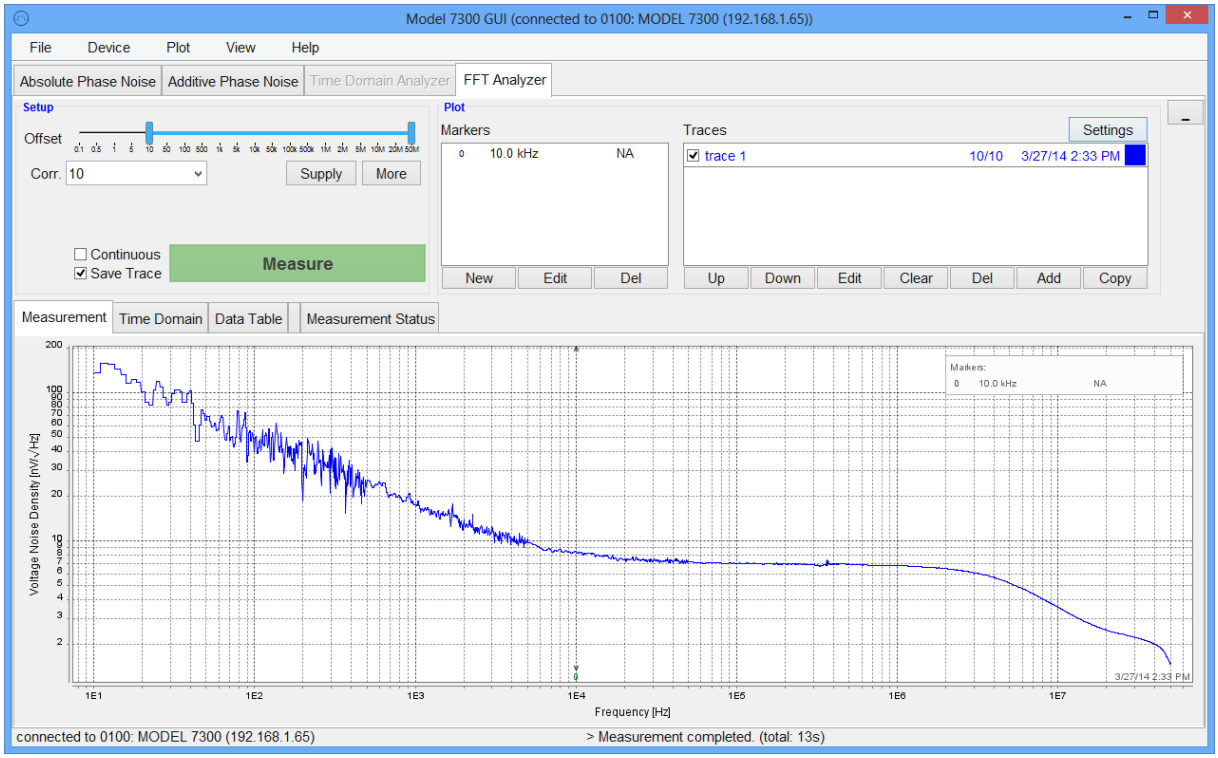


Figure 21 FFT Analyzer Mode

3.9 VCO Characterization

The VCO characterization tab provides the possibility to fully characterize a VCO, including Kvco, current draw, power output, pushing and spot phase noise over a specified control voltage range by the means of a single button click.

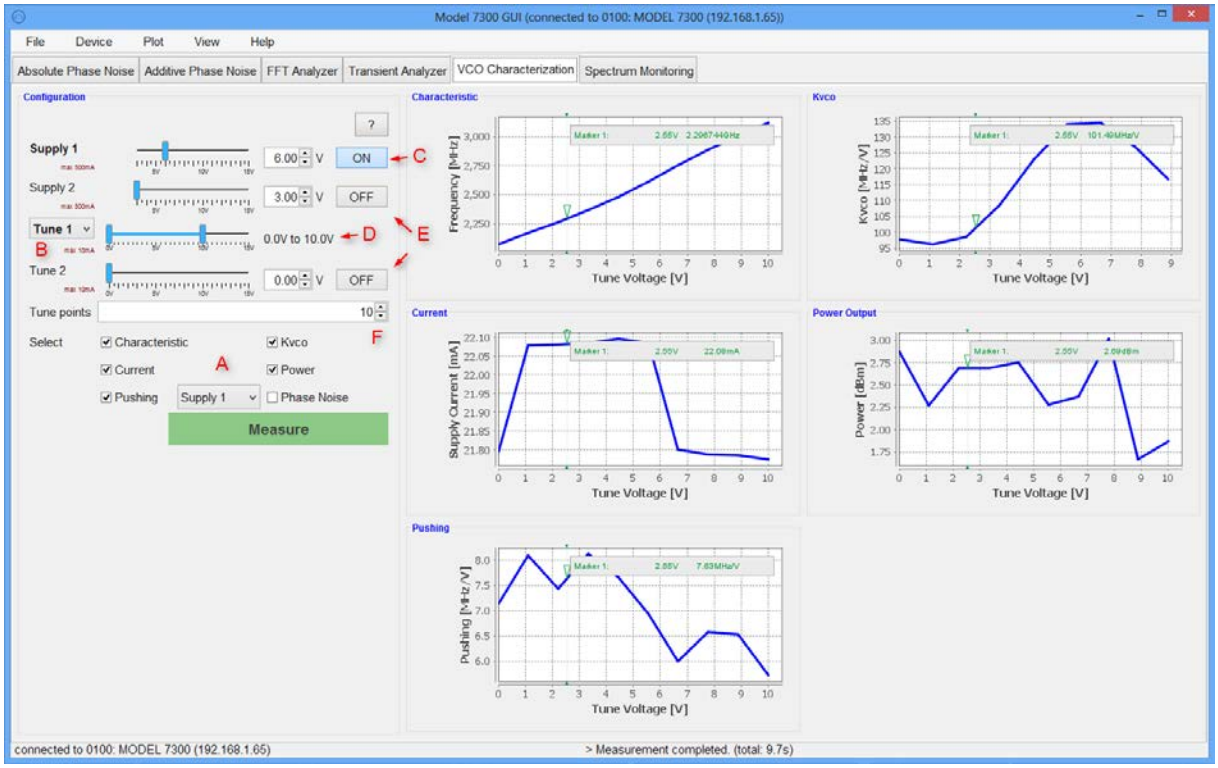


Figure 22 VCO characterization tab.

3.9.1 Measurement Procedure

Connect the VCO to the SERIES 7000, using one of the supply outputs on the back panel of the SERIES 7000 as supply voltage for the VCO, one of the tune outputs on the front panel of the SERIES 7000 as control voltage and connect the RF output of the VCO to the DUT in of the SERIES 7000.

Next, select the connected supply and tune ports in the VCO characterization tab (A and B). Then set the supply voltage (C) and turn on the supply voltage by clicking on the ON/OFF button. Select the tuning range of your VCO (D). The unused supply and tune port can be used as additional voltages if needed and can be set accordingly (E). Choose the number of tune points for the measurement. Those points will be equally distributed within the selected tune range. With the checkboxes around A, the individual measurement parameters can be enabled/disabled.

A click on the green measurement button will start the measurement. The process will go through all tune voltage points and measure the enabled parameters.

Every plot has a single marker showing. The markers can be synchronously moved by dragging it with the mouse on any of the displayed plots.

4 System Calibration (Firmware 1.0 and up)

User calibration is a function to correct the frequency response using correction data set for phase noise, amplitude and baseband noise measurements.
This chapter describes the correction method and how to set up the calibration procedure.

User calibration procedure will be supported from firmware and remote client revision 1.0

Please contact support@Berkeley Nucleonics.com to check availability.

5 Remote Programming the SERIES 7000

The SERIES 7000 can be remote controlled via three independent but functionally equivalent interfaces: USBTMC, LAN, and (optionally) GPIB.

5.1 Access via LAN

The signal analyzer can be remotely programmed via a 10/100/1000Base-T LAN interface and LAN-connected computer using one of several LAN interface protocols. The LAN allows instruments to be connected together and controlled by a LAN- based computer. LAN and its associated interface operations are defined in the IEEE 802.2 standard.
The SERIES 7000 supports the following LAN interface protocols:

1) **Socket based LAN:** proprietary function calls defined in the dynamic link library (DLL) provided with the instrument, used for general programming using the LAN interface under Windows operating system.
2) **VXI-11/SCPI** (version 1999) commands (firmware 1.0 upwards)
3) **Telephone Network** (TELNET): TELNET is used for interactive, one command at a time instrument control

For LAN operation, the instrument must be connected to the LAN, and an IP address must be assigned to the instrument either manually or by using DHCP client service. Your system administrator can tell you which method to use. (Most current LAN networks use DHCP.)

DHCP Configuration

If the DHCP server uses dynamic DNS to link the hostname with the assigned IP address, the hostname may be used in place of the IP address. Otherwise, the hostname is not usable.

5.2 Using and Configuring VXI-11

The analyzer supports the LAN interface protocol described in the VXI- 11 standard. VXI- 11 is an instrument control protocol based on Open Network Computing/Remote Procedure Call (ONC/RPC) interfaces running over TCP/IP.

A range of standard software such as NI-VISA or Agilent IO Config is available to setup the computer/analyzer interface for the VXI- 11 protocol. Please refer to the applicable software user manual and documentation for information on running the program and configuring the VXI-11 interface. The program is used to configure the LAN client. Once the computer is configured for a LAN client, you can use the VXI- 11 protocol and the VISA library to send SCPI commands to the signal generator over the LAN interface. Example programs are available on request under support@Berkeley Nucleonics.com.

VISA is an IO library used to develop IO applications and instrument drivers that comply with industry standards. It is recommended that the VISA library be used for programming the signal source analyzer. The NI-VISA and Agilent VISA libraries are similar implementations of VISA and have the same commands, syntax, and functions.

5.3 Using the USB-TMC Interface with VISA

The USB (Universal Serial Bus) remote control system provides device control via USB, which is equivalent to control via LAN or GPIB. Connection is made through an interface in compliance with USBTMC-USB488 and USB 2.0

Type B: USB (USBTMC) interface port

The SERIES 7000 conform to USB Test & Measurement Class (USBTMC) protocol. This simplifies instrument control considerably because such devices behave just like GPIB devices when communicating.
You must install the VISA Libraries on your PC in advance. The USB can identify devices automatically, so once you connect a USB cable to a target device, a dialog box will appear for USB device registration.

Please see the SERIES 7000 Programmer's Manual for detailed description of supported SCPI commands.

5.4 Using the USB-TMC Interface with IVI drivers

Please see the SERIES 7000 Programmer's Manual for detailed description of supported SCPI commands.

5.5 Using the GPIB Interface

This section describes how to set the interface necessary to use the GPIB (General Purpose Interface Bus) of the SERIES 7000.
The GPIB interface operates with IEEE488.2 and SCPI. The instrument can be controlled by a GPIB external controller. When controlling the SERIES 7000 using GPIB commands from the external controller connected to the GPIB connector, you need to set the talker/listener GPIB address of the SERIES 7000.

Please see the SERIES 7000 Programmer's Manual for further details.

6 Type and Structure of Commands

The SCPI commands available for the SERIES 7000 are classified into 2 groups as follows.

6.1 SERIES 7000 commands

Commands specific to the SERIES 7000. They cover all measurement functions that the SERIES 7000 has and some general-purpose functions. The commands in this group are arranged in a hierarchical structure called the command tree. Each command consists of character strings (mnemonics) indicating each hierarchical level and colon (:) separators between hierarchical levels.

6.1.1 IEEE common commands

Commands to cover general-purpose functions defined in IEEE488.2 that are available commonly to instruments that support this standard. The commands in this group have an asterisk (*) at the beginning. For the commands in this group, there is no hierarchical structure.

6.1.2 Using SCPI for SERIES 7000

Berkeley Nucleonics instrument are message based, which means they are controlled through text commands, typically following the SCPI standard which is vendor-independent and interface-independent. Berkeley Nucleonics devices offer several I/O options use the same SCPI commands through all these interfaces, especially LAN and USB.

Please see the SERIES 7000 Programmer's Manual for detailed description of supported SCPI commands.

7 Maintenance and Warranty Information

7.1 Adjustments and Calibration

To maintain optimum measurement performance, the SERIES 7000 should be calibrated every 24 months. It is recommended that the SERIES 7000 be returned to Berkeley Nucleonics or to an authorized calibration facility. For more information please contact our Customer Service Department at support@Berkeley Nucleonics.com or through our website.

7.2 Repair

The instrument contains no user-serviceable parts. Repair or calibration of the SERIES 7000 requires specialised test equipment and must be performed by Berkeley Nucleonics or its authorized repair specialists.

7.3 Upgrading the Firmware via LAN

It is recommended to regularly check for new firmware for the SERIES 7000. If new firmware is available, it can be downloaded from the Berkeley Nucleonics website and locally stored. Then, it can be uploaded directly to the instrument via Device → Upload Firmware

7.4 Safety

FCC notice

This equipment has been tested and found to comply with the limits for a Class A device, pursuant to **Part 15 of the FCC Rules**. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications.
Operation of this equipment in a residential area may cause harmful interference. In which case the user will be required to correct the interference at his or her own expense.

CE notice

The SERIES 7000 meets the intent of the **EMC directive 89/336/EEC** and have been designed to **EN61326 Class A Emissions and Immunity** standard.

The SERIES 7000 also meets the intent of the **Low Voltage Directive** and have been designed to meet the **IEC 61010-1:2001** (safety requirements for electrical equipment, control, and laboratory use) standard.

7.5 Warranty Information

All Berkeley Nucleonics instruments are warranted against defects in material and workmanship for a period of two years from the date of shipment. Berkeley Nucleonics will, at its option, repair or replace products that prove to be defective during the warranty period, provided they are returned to Berkeley Nucleonics and provided the preventative maintenance procedures are followed. Repairs necessitated by misuse of the product are not covered by this warranty. No other warranties are expressed or implied, including but not limited to implied warranties of merchantability and fitness for a particular purpose. Berkeley Nucleonics is not liable for consequential damages.
The warranty on the internal rechargeable batteries (option B3) is one year from the date of shipment. Battery replacement is available through Berkeley Nucleonics and its distributors.

IMPORTANT NOTE: the warranty is voided if instrument is opened by not instructed personnel.

7.6 Equipment Returns

For instruments requiring service, either in or out of warranty, contact your local distributor or Berkeley Nucleonics Customer Service Department at the address given below for pricing and instructions before returning your instrument or go to Berkeley Nucleonics website for RMA requests.

Be sure to have the following information available:

- Model number.
- Serial number.
- Full description of the failure condition.

Note: Model and serial number can be found on the rear of the SERIES 7000 unit, next to the power plug.
You will get a Return Mechandise Authorization (RMA) number from Berkeley Nucleonics, please put it on the outside of the package.
Instruments that are eligible for in-warranty repair will be returned prepaid to the customer. For all other situations the customer is responsible for all shipping charges. An evaluation fee may be charged for processing units that are found to have no functional or performance defects.
For out of warranty instruments, Berkeley Nucleonics will provide an estimate for the cost of repair. Customer approval of the charges will be required before repairs can be made. For units deemed to be beyond repair, or in situations where the customer declines to authorize repair, an evaluation charge may be assessed by Berkeley Nucleonics.